IN THE MATTER OF	The Resource Management Act 1991
AND	
IN THE MATTER OF	applications for resource consents in relation to Te Ahu a Turanga; Manawatū Tararua Highway Project
BY	**NEW ZEALAND TRANSPORT AGENCY** Applicant

TE AHU A TURANGA: TECHNICAL ASSESSMENT H

Freshwater Ecology

TAT-0-EV-06001-CO-RP-0009

TABLE OF CONTENTS

INTRODUCTION

1. My full name is Justine Louisa Quinn. I am a freshwater scientist at Tonkin and Taylor Limited, and I am the author of this report.

2. I have been providing advice on freshwater ecology matters related to the proposed Te Ahu a Turanga Project (the "**Project**") to the Te Ahu a Turanga Alliance ("**Alliance**"), and ultimately Waka Kotahi NZ Transport Agency ("**Transport Agency**"), since September 2019.

3. My contributions include:

    (a) Preparing this assessment of the Project's effects on freshwater ecology based on the updated alignment and detailed design;

    (b) Designing and undertaking follow-up field surveys to fill gaps identified during the process of preparing and considering the Notices of Requirement for designations ("**NoRs**") for the Project, and to inform the development of an ecological effects management framework;

    (c) Inputting to refining the Project footprint in response to further field surveys;

    (d) Inputting to the natural character assessment in respect of freshwater ecological values;

    (e) Overseeing the preparation of the Freshwater Ecology Management Plan ("**FEMP**"), a component of the Ecology Management Plan ("**EMP**"), including Fish Recovery Protocols ("**FRP**") and Aquatic Ecology Monitoring Protocols ("**AEMP**");

    (f) Leading a team of freshwater ecologists and working with the broader ecological team to prepare an offset package to address the unavoidable, residual adverse effects of the Project on freshwater ecology; and

    (g) Attending and participating in ecology workshops and hui with the Department of Conservation ("**DOC**") and Horizons Regional Council ("**Horizons**").

Qualifications and experience

4. I have the following qualifications and experience relevant to this assessment:

    (a) I hold the qualifications of Bachelor of Science (Biology, 2006), a Postgraduate Diploma of Science with Distinction (Environmental

Science, 2010) and a Masters of Legal Studies (Hons) (Environmental Law, 2016), all from the University of Auckland.

(b) I have been a Certified Environmental Practitioner (#604) since 2014. I am a member of the New Zealand Freshwater Sciences Society, the Environment Institute of Australia and New Zealand ("**EIANZ**") and the Resource Management Law Association. I have been active within EIANZ since joining in 2010, holding several roles on the Executive Committee and Auckland Branch, most recently as a mentor.

(c) I hold the position of Senior Freshwater Scientist at Tonkin & Taylor Limited ("**T+T**"), Environmental and Engineering Consultants. I have thirteen years' experience in the field of freshwater science and have worked at T+T since February 2017.

(d) I have previously been employed in the following positions: Senior Freshwater Scientist at Golder Associates (NZ) Ltd (2015-2016), Senior Consents and Compliance Specialist, Stormwater and Industrial and Trade Activities Team, Natural Resources and Specialist Input (Resource Consents) at Auckland Council (2012-2014), Environmental Scientist at Morphum Environmental Ltd (2007-2012), and Graduate Scientist at Bioresearches (2006-2007).

(e) I specialise in water quality and aquatic ecology resource evaluation and management work in freshwater environments. I undertake project work for a range of local authority, industry and developer clients throughout New Zealand. My project work typically includes technical advice on water quality and freshwater ecology matters, undertaking small to large scale water quality and ecological evaluations, designing and implementing of monitoring and field assessment programmes, and assessing the environmental effects for small and large projects affecting aquatic environments.

(f) I am experienced in the application of the stream ecological valuation ("**SEV**") method, having contributed to the 2011 revised version and being a co-author on recent application of the method to intermittent streams. I regularly apply the SEV method, associated environmental compensation ratio ("**ECR**") and principles of offsetting to developments where stream loss or modification is unavoidable.

Code of conduct

5. I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2014. This assessment has been prepared in compliance with that Code, as if it were evidence being given in Environment Court proceedings. In particular, unless I state otherwise, this assessment is within my area of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

Purpose and scope of assessment

6. The purpose of this assessment is to inform the regional consenting process by:

   (a) Describing the ecological values and characteristics of the freshwater environment;

   (b) Identifying and assessing the actual and potential ecological effects of the Project; and

   (c) Recommending measures to manage those ecological effects.

7. In undertaking my assessment of ecological effects, I have reviewed information presented during the Project's Notices of Requirement for designations ("**NoR**") process and used this as a basis for further site investigations.

8. I have checked and verified the information presented during the NoR process and where necessary, overseen the collection of new information and additional detailed freshwater ecology assessments.

9. My assessment has been developed with reference to:

   (a) The updated alignment and detailed design information, as set out in the Design and Construction Report ("**DCR**") and Drawing Set (referred to below);

   (b) The effective management actions outlined in the proposed management plans; and

   (c) The freshwater ecology effects management framework outlined within this assessment.

10. This assessment is limited to freshwater ecology effects resulting from the Project and associated measures proposed to address these effects. My

assessment should be read in conjunction with the following subject matter expert reports that have been developed to support the Assessment of Effects on the Environment ("**AEE**"):

(a) **Mr Campbell Stewart's** technical assessment (A) provides recommendations to manage erosion and sediment during construction;

(b) **Mr David Hughes'** technical assessment (B) describes the stormwater management approach proposed for the Project.

(c) **Mr Keith Hamill's** technical assessment (C) covers the impacts of the construction and stormwater discharges on water quality in the receiving environment;

(d) **Dr Jack McConchie's** technical assessment (D) covers the impacts of the stormwater discharges on hydraulic performance of the receiving environment, including the effects of piers and bridge abutments associated with the proposed bridges over the Manawatū River and the Mangamanaia Stream;

(e) **Dr Matt Baber's** technical assessment (F) addresses ecological effects on terrestrial and wetland vegetation ecology;

(f) **Mr Josh Markham's** technical assessment (G) addresses the offset and compensation package proposed to address residual terrestrial and wetland effects; and

(g) **Mr Boyden Evans'** technical assessment (I) addresses the effects of the project on natural character. I have contributed to this natural character assessment specifically in respect of freshwater ecology.

11. I acknowledge the cultural values that underpin this Project, particularly those with relevance to the importance of water to tangata whenua. Cultural impact assessments have been prepared in respect of the Project and these address water and freshwater ecology impacts from a mana whenua perspective.

Assumptions and exclusions in this assessment

12. My assessment addresses the freshwater ecology effects anticipated from the 'Main Works' of the Project as described in the DCR, as detailed in section 3

of the AEE Report and on the Drawing Set in Volume 3 of the Application. My assessment includes consideration of the following:

(a) construction of the road alignment including all associated earthworks, culverts, stream diversions (and consequential stream infilling)[1] and bridges (including but not limited to the new bridge over the Manawatū River, referred to as BR02);

(b) ongoing operation, maintenance and use of the road;

(c) proposed spoil sites including any culverts, stream diversions and consequential stream infilling;

(d) Meridian access tracks including all associated earthworks culverts, stream diversions and consequential stream infilling;

(e) the shared use path and other ancillary tracks, paths and boardwalks;

(f) car parking, rest areas, viewing platforms and any associated facilities including those associated with the western entrance to the Manawatū Gorge Scenic Reserve ("**MGSR**") (replacement toilets, community facilities);

(g) construction methodologies associated with the construction of the above as described in the DCR and in Technical Assessment D: Erosion and Sediment Control Assessment (Volume V) including the associated Erosion and Sediment Control Plan ("**ESCP**") (Volume VII).

13. Enabling works activities are currently underway and include geotechnical investigations, a water take permit and creation of access tracks to the Project area from the public road network. Some enabling works require Resource Management Act 1991 ("**RMA**") consents and these have been or will be applied for and obtained independently of the Main Works consents. The enabling works including those that have been consented are described in section 3 of the AEE Report.

14. Effects on freshwater ecology values associated with enabling works have been or will be considered as part of the consent applications for those works. I note that no enabling works consented to date have had residual (after mitigation) freshwater ecology effects that require offsetting.

[1] The Horizons One Plan identifies deposition of a substance as an activity, however does not define the activity following diversion, being to fill in the bed of an existing/ remnant stream such that part of the stream no longer functions. Within this assessment the term 'infilling' is used to describe this effect on freshwater systems.

EXECUTIVE SUMMARY

15. The Transport Agency is proposing to construct an 11.5 km road between Ashhurst and Woodville via a route over the Ruahine Ranges. The Project is intended to replace the indefinitely closed section of State Highway 3 ("**SH3**") through the Manawatū Gorge.

16. This report assesses the effects of the construction and operation of the Project on freshwater ecological values.

Existing freshwater ecology environment

17. The Project alignment involves work within nine catchments of the Manawatū River including bridges across the Mangamanaia Stream and Manawatū River.

18. Field surveys were undertaken in 2018 to inform NoR reporting. This involved fishing, stream ecological valuations and macroinvertebrate sampling at eight sites across six catchments.

19. Further field surveys were undertaken between August and November 2019 following refinement of the Project alignment (to provide for the 'Northern Alignment') and footprint. Stream ecological valuations and macroinvertebrate sampling was conducted at 26 sites. Fish surveys were undertaken at six sites. Stream classifications and basic descriptions were undertaken for almost all stream length under the Project footprint.

20. Most of the stream catchments are short and steep, with unvegetated headwaters, modified through agricultural land use. The lower reaches of these catchments are within the MGSR and of markedly higher quality. Queen Elizabeth the Second National Trust ("**QEII**") open space covenants over areas of bush within catchment 7, 6 and 4 are also of high quality and effects are, for the most part, avoided. Many of the stream systems are hard-bottom, however fine sediment deposition is present in most catchments and is expected to influence the fauna present.

21. Macroinvertebrate indices varied across the alignment, with stream length through areas of agricultural land use indicative of 'poor' to 'fair' water and habitat quality. Parts of upper catchment 2C and 5 are of surprisingly good quality with macroinvertebrate communities typical of good water and habitat quality despite the surrounding land use.

22. Fish communities were more diverse in the lowland areas of Mangamanaia Stream and Manawatū River. Existing natural and artificial barriers are expected to have contributed to a reduced diversity in the upper reaches of headwater catchments. Many of the headwaters streams being affected by the project have narrow, intermittent channels offering temporary lower value habitat.

Identifying and assessing effects

23. The potential effects on freshwater ecology resulting from the Project have been assessed in terms of short- and long-term effects.

24. Short-term effects relate to effects during the construction phase which could include fish injury and/or mortality, temporary fish passage restrictions, and water quality effects resulting from sedimentation, hazardous substances and cut vegetation storage. These construction effects can be minimised through the implementation of fish salvage protocols, vegetation clearance (and storage) protocols, hazardous substance procedures and good practice sediment and erosion control measures. The proposed routine and responsive monitoring at sediment ponds and within the environment will assist in the management of potential sediment effects.

25. Potential long-term effects anticipated to occur from the Project include reduced fish passage, water quality effects, changes to hydrology and loss of stream ecological function and habitat area. A variety of measures to avoid, minimise and mitigate effects are proposed to be implemented, including provision of fish passage, stormwater management approach developed to a high standard, electing to construct stream diversions in preference to piping and where these can be built ensure that they are designed and built so as to deliver best practicable ecological and conveyance outcomes. These proposed constructed stream diversion channels will be designed and constructed to mimic existing natural situations.

26. While many of the potential effects have been avoided, or minimised and mitigated to the extent possible, there are residual adverse effects resulting from the loss and modification of stream habitat. These residual effects are proposed to be addressed by additional measures aimed at achieving no net loss of ecological function.

27. The SEV and Ecological Compensation Ratio ("**ECR**") method[2,3] has been used to quantify the enhancement measures required to achieve no net loss of ecological function by assessing ecological 'losses' at impact sites and ecological 'gains' resulting from the creation of new stream habitat and enhancement of existing, degraded headwater catchments.

28. Impacts on 13.365 km intermittent and permanent stream can be offset to achieve a no net loss in ecological function through the construction of Type 1, 2 and 3 stream diversions and riparian planting and fencing of intermittent and permanent streams. The final location and precise composition of the offset package will be determined following further discussions with landowners, however (as discussed below) two areas have been identified which have been modelled to show that sufficient stream length to achieve no net loss in ecological function can be achieved.

29. One of the proposed enhancement planting sites is within the Mangamanaia Stream catchment and would involve several headwater gully systems being retired and planted. This would contribute to catchment scale benefits beyond just the stream reach (and what the SEV method can reasonably capture).

30. During the construction process efforts will be made to refine the design to further reduce effects on streams. Accordingly, the final amount of stream offset required will be calibrated to reflect the effects of the Project and the ecological gains that are achieved.

31. Overall I consider that the effects of the Project on freshwater ecology can be avoided, minimised or mitigated and residual effects can be offset to achieve a no net loss of ecological function. I consider that the measures proposed are sufficient to address the effects associated with this Project and will result in a positive overall outcome within the immediate Manawatū River catchment.

PROJECT DESCRIPTION

32. The Project comprises the construction, operation, use, maintenance and improvement of approximately 11.5km of State highway connecting Ashurst

[2] Storey, R G, Neale, M W, Rowe, D K, Collier, K J, Hatton, C, Joy, M K, Maxted, J R, Moore, S, Parkyn, S M, Phillips, N and Quinn, J M (2011). Stream Ecological Valuation (SEV): a method for assessing the ecological function of Auckland streams. Auckland Council Technical Report 2011/009.
[3] Neale, M W., Storey, R G and Quinn, J L (2016). Stream Ecological Valuation: application to intermittent streams. Prepared by Golder Associates (NZ) Limited for Auckland Council. Auckland Council technical report, TR2016/023.

and Woodville via a route over the Ruahine Range. The purpose of the Project is to replace the indefinitely closed existing SH3 through the Manawatū Gorge.

33. The Project comprises a median separated carriageway that includes two lanes in each direction over the majority of the route and will connect with State Highway 57 ("**SH57**") east of Ashhurst and SH3 west of Woodville (via proposed roundabouts). A shared use path for cyclists and pedestrian users is proposed as well as a number of new bridge structures including a bridge crossing over the Manawatū River.

34. The design and detail of each of the elements of the Project are described in:

    (a) Section 3 of the Assessment of Environmental Effects ("**AEE**") (Volume I of the application materials);

    (b) the Design and Construction Report ("**DCR**") contained at Volume II; and

    (c) the Drawing Set (contained in Volume III).

35. The elements of the Project that are particularly relevant to this assessment are those associated with main works as follows:

    (a) Sixteen spoil sites;

    (b) Culverts comprising a total 2,361 m including:

        (i) 25 road culverts;

        (ii) 8 access road culverts;

    (c) 8,014 m constructed stream diversions comprising:

        (i) Type 1 Lowland Stream - 2,044 m (average 1.8 m width);

        (ii) Type 2 Steep Stream - 3,892 m (average 1.5 m width);

        (iii) Type 3 Intermittent Stream - 2,1078 m (average 1.1 m width);

    (d) Type 4 cut off drains to provide for overland flow;

    (e) Diversion of stormwater to stormwater wetlands and wetland swales for water quality treatment and detention;

    (f) Erosion and sediment control measures implemented over the earthworks areas to be managed according to site specific controls; and

    (g) Temporary stormwater quality measures associated with construction laydown areas.

EXISTING ENVIRONMENT

36. For the purposes of this assessment, I have considered the existing environment on the basis that it does not include any confirmed Project NoRs or designations.

37. With regard to freshwater ecology, the existing environment was assessed to inform the NoR process[4] and then further, more detailed investigations have been undertaken to inform the regional consent process.

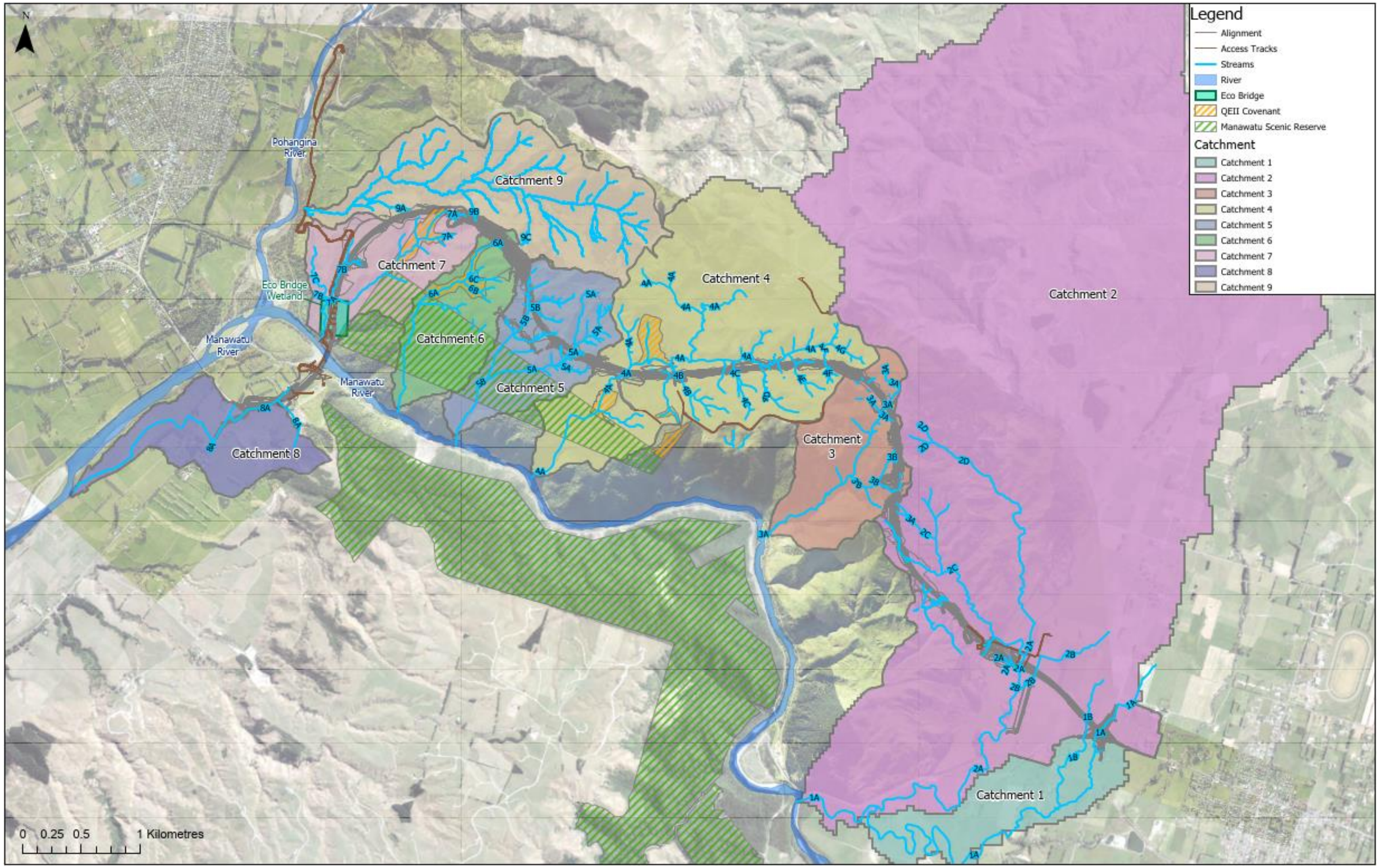
38. A brief outline of the key freshwater ecology features of the Project site is provided below. Within this assessment, I refer to information reported during preceding investigation phases of the Project where appropriate. However, I rely primarily on field investigations undertaken in September and October 2019 (described further in sections following).

39. The Project alignment is located within the Manawatū River catchment. The Manawatū River flows through the Manawatū Gorge in a westerly direction to the south of the Project alignment.

40. Nine catchments of the Manawatū River, and the River itself, have been identified as being directly or indirectly impacted by the Project. Catchments have been assigned identifiers[5] (numbers) from 1 to 9, starting on the eastern end of the alignment (Figure H.1).

[4] Technical Assessment 6.C as lodged with the NoRs (and its appendices), and the evidence of Mr Miller presented at the council-level hearing of the NoRs.
[5] These catchment numbers are consistent with those used in the NoR documentation.

Figure H.1: Affected catchments along the proposed alignment.



41. A brief summary of the key characteristics of the catchments is provided, as follows. Representative photos from across the affected reaches are provided in Appendix 5 of Technical Assessment I (Natural Character).

42. **Catchment 1** is approximately 1.17 km^2 and drains a predominantly low lying area. It is the most eastern affected catchment and is characterised by highly modified and degraded stream systems flowing through agricultural land use.

43. **Catchment 2** is the Mangamanaia Stream, which at 20.55 km^2 is the second largest catchment affected by the Project. The western headwaters of Catchment 2 are located at the base of the Ruahine Range and are steep, gully systems. Conversely the eastern headwaters are in a gentler topography. Much of the catchment is currently in agricultural land use which is expected to have negatively impacted water quality.

44. **Catchment 3** is a steep short catchment (1.23 km^2) with forested areas in the mid to upper reaches. The headwaters are modified resulting from some agricultural land use and the lower reaches have been denuded of vegetation.

45. **Catchment 4** is the largest of those affected along the ridgeline at 4.12 km^2. Most of the upper reaches have been modified through agricultural land use, with stock access generally unrestricted and streams dammed to create farm ponds. One of the sub-catchments within Catchment 4 is within land subject to a QEII Open Space Covenant. The lower reaches of the main stem through Catchment 4 are steep and flow through native forest (within the MGSR) before discharging to the Manawatū River within the Gorge.

46. **Catchment 5** is 1.2 km^2 and comprises two main tributaries (5A and 5B). The upper reaches of these sub-catchments are characterised by steep, hard bottom stream systems in agricultural land use with fragmented riparian margins. The main stem of Catchment 5 is located within the MGSR, with 5A to the upper east and 5B to the upper west.

47. **Catchment 6** (0.95 km^2) is located within land subject to a QEII Open Space Covenant in its upper reaches and then enters the MGSR before discharging to the Manawatū River through the Gorge. The headwaters are located within agricultural land use, however, the riparian margins are partially vegetated and protected from stock.

48. **Catchment 7** comprises three main branches (7A, 7B and 7C) with a total catchment area of 1.10 km^2. The three branches converge within an area of high value raupō wetland before discharging to the Manawatū River

downstream of the Gorge. The headwaters of sub-catchment 7B and 7C are in agricultural land use, with increasing vegetation down the catchment. Sub-catchment 7A is within land subject to a QEII Open Space Covenant and is particularly steep in the upper reaches.

49. **Catchment 8** (1.01 km^2) is the only affected catchment on the southern side of the Manawatū River. The lower reaches are highly modified adjacent to the road corridor resulting from agricultural land use.

50. **Catchment 9** (Mangakino catchment) is located to the north of the alignment and flows west to east. The catchment is approximately 2.20 km^2 and is a tributary of the Pohangina River. The topography of the catchment is steep and the majority of the stream reaches are well vegetated.

METHODOLOGY

Background

51. The Transport Agency's three NoRs for the Project are currently under appeal. I understand that the Transport Agency will ask the Environment Court, as part of those appeals, to modify the NoRs to provide for the Northern Alignment on which the Project design is based.[6]

52. I have familiarised myself with the technical assessments previously prepared by the Transport Agency in support of the NoRs in relation to freshwater ecology, including:

    (a) Technical Assessment 6C: Freshwater Ecology (and its appendices).

    (b) Technical Assessment 4: Landscape, Natural Character and Visual (and its appendices).

    (c) Statement of Evidence of **Mr Miller** dated 8 March 2019 and the addendum dated 25 March 2019.

    (d) The Territorial Authority Recommendation Report, and the Transport Agency's Notice of Decision confirming the NoRs including the decision version of the condition set dated 7 June 2019.

53. I have also had regard to the Transport Agency's updated proposed conditions for the Project designations, being the version dated 15 October 2019 agreed between the Transport Agency and a range of parties to the Environment Court appeals against the Transport Agency's decision to confirm the designations

[6] Refer to the DCR for a description of the Northern Alignment and overall Project design.

("**Designation Conditions**"). The Designation Conditions focus primarily on land-use matters (including for example terrestrial ecology). However, there are Designation Conditions that are relevant to this assessment, including in particular:

(a) Condition 3 and 4 which details the certification requirements and subsequent amendments process for the EMP required by condition 24;

(b) Condition 9 (e) and 24 (a) v) which specify the maximum length of QEII Trust west (stem 7A) and QEII Trust east (stems 6A, 6B and 6C) streams that may be disturbed.

(c) Condition 24 which details the ecological performance standards and the requirements of the EMP.

(d) Condition 25 which specifies specific discovery protocols for At Risk or Threatened flora and fauna.

54. I reviewed NoR Technical Assessment 6C and used this as a basis for determining where further investigations were required to inform the assessment of effects on freshwater ecology values for the main works resource consent applications. This current assessment provides more detail and further refines that previous assessment of ecological effects based on:

(a) The updated alignment and detailed design information;

(b) The regional consents being sought to enable the Project;

(c) The effective management actions outlined in the proposed management plans (which I have been closely involved in developing); and

(d) The freshwater ecology effects management framework outlined within this assessment.

55. When I come to consider effects management measures for the Project, I have been conscious of what has been proposed to date through the Designation Conditions.

Assessment Methodology

56. I have assessed the freshwater ecological values and the magnitude of effects of the Project on these values, using current best practice methods outlined in EIANZ Ecological Impact Assessment Guidelines[7] ("**EcIAG**").

57. The EcIAG were prepared to provide nationally consistent direction on the approach to be adopted when assessing ecological impacts. In brief, the EcIAG approach involves four steps, summarised as follows and presented in APPENDIX H.1: Ecological Impact Assessment Guidelines.

58. **The level of ecological value of the environment (Step 1)**:

    (a) The EcIAG do not provide a unifying set of attributes used to assign value to freshwater systems. However, there are numerous widely accepted metrics and measures that are used in the assessment of freshwater systems.

    (b) For the purposes of this assessment I have adapted a freshwater values criteria based on the EcIAG and developed by Boffa Miskell Limited[8] (Table H.19, APPENDIX H.1: Ecological Impact Assessment Guidelines) which assigns ecological value based on biodiversity and ecological function values of the freshwater systems.

    (c) These criteria recognise existing standard approaches to freshwater assessment including macroinvertebrate community indices,[9][10][11] fish index of biotic integrity[12] ("**IBI**") and SEVs.[13]

59. **The magnitude of ecological effect from the proposed activity on the environment (Step 2)**:

    (a) Magnitude of effect is a measure of the extent or scale of the effect of an activity and the degree of change that it will cause. The magnitude of an effect is scored on a scale of Negligible to Very High (Table H.20,

---

[7] Roper-Lindsay, J., Fuller, S.A., Hooson, S., Sanders, M.D., and Ussher, G.T. (2018). Ecological Impact Assessment. EIANZ guidelines for use in New Zealand: terrestrial and freshwater ecosystems. 2nd edition.
[8] Boffa Miskell Limited have developed these assessment criteria and applied them to a wide range of projects.
[9]Stark, J D, Boothroyd, I K G., Harding, J S, Maxted, J R, & Scarsbrook, M R (2001). Protocols for sampling macroinvertebrates in wadeable streams. Prepared for the Ministry for the Environment.
[10] Stark, J D, and Maxted, J R (2007). A user guide for the macroinvertebrate community index. Prepared for the Ministry of the Environment. Cawthron Report No. 1166. 58p.
[11] Stark, J D, and Maxted, J R (2007). A biotic index for New Zealand's soft-bottomed streams. New Zealand Journal of Marine and Freshwater Research 41(1).
[12] Joy, M. (2015) A Fish Index of Biotic Integrity (IBI) for Horizons Regional Council. Report and user guide for use with the Horizons Fish IBI excel macro Report by Mike Joy and excel macros by Ian Henderson Ecology group Massey University Palmerston North JUNE 2015.
[13] Storey et al (n 2) and Neale et al (n 3)

APPENDIX H.1: Ecological Impact Assessment Guidelines) and is assessed in terms of:

(i) Level of confidence in understanding the expected effect;

(ii) Spatial scale of the effect;

(iii) Duration and timescale of the effect (Table H.21, APPENDIX H.1: Ecological Impact Assessment Guidelines);

(iv) The relative permanence of the effect; and

(v) Timing of the effect in respect of key ecological factors.

(b) For avoidance of doubt, I have considered the nature and magnitude of the ecological effect at the physical point of impact with recognition of the effect at a local and landscape spatial scale context as appropriate.

60. **The overall level of effect to determine if mitigation is required (Step 3)**:

(a) An overall level of effect is identified for each activity and catchment using a matrix approach that combines the ecological values (described in [58] above) with the magnitude of effects (described in [59] above) resulting from the activity (Table H.22, APPENDIX H.1: Ecological Impact Assessment Guidelines).

(b) The matrix describes an overall level of effect on a scale of Negligible to Very High. Positive effects are also accounted for within the matrix.

(c) The level of effect is then used to guide the extent and nature of the ecological effects management response required, which may include avoidance, remediation, mitigation, offsetting or compensation.

61. **The magnitude and overall level of effect following implementation of measures to avoid, remedy, mitigate the effects (Step 4, repeating Step 2 and 3)**.

62. The overall level of effects on each catchment value is assessed before and after recommendations to avoid, remedy or mitigate effects. As such, the need for and extent to which recommendations are made to reduce effects, if implemented, is clearly understood.

63. While offsetting and compensation form a key component of the effects management framework for this Project, these measures are not taken into account when assessing the overall effect in steps under the EcIAG approach.

Rather offset and compensation are considered a response to that level of residual adverse of effect.

Literature review

64. Information used to inform my EcAIG assessment outlined above was gathered through a combination of literature review and site investigations.

65. Multiple project-specific freshwater ecological and water quality assessments have now been undertaken across the NoR designation corridor (including the corridor as it would be modified to provide for the Northern Alignment). Review of these reports has informed my understanding of the freshwater ecological values across the alignment.

66. The key reports reviewed include:

    (a) Those referred to at [52] above;

    (b) Evidence presented through the NoR process; and

    (c) Baseline Freshwater Monitoring Results.[14]

67. The ecological databases listed below were also reviewed to ensure the most recent data available was included in this assessment:

    (a) Land, Air, Water Aotearoa ("**LAWA**"); and

    (b) New Zealand Freshwater Fish Database ("**NZFFD**") administered by the National Institute of Water and Atmospheric Research ("**NIWA**").

Site Investigations

68. The following section outlines the additional assessments undertaken to inform this assessment of ecological effects and includes:

    (a) Stream classification and extent under the proposed Project footprint;

    (b) SEVs at 26 sites across the project footprint to quantify the ecological value of impacted streams;

    (c) Macroinvertebrate surveys at SEV sites;

    (d) Fish surveys at six sites to supplement the existing fish presence data; and

[14] James, A. (2019). Te Ahu a Turanga: Manawatū Tararua Highway – Baseline Freshwater Monitoring Results. Report prepared by EOS Ecology. November 2019. Report number NZT02-18064-03.

(e) SEVs at several representative proposed offset sites to inform offset modelling.

Stream classification and extent

69. Using the catchments identified during the NoR assessment as a starting point, all stream length under the proposed Project footprint (as at design version 26a)[15] was walked by field staff (under my supervision) and mapped on ArcGIS. I have reviewed the findings and results of these surveys which include detailed photographic records.

70. The following attributes were captured for each reach[16] using a multi choice assessment criteria (shown in brackets).

(a) Stream classification (ephemeral, intermittent, permanent, artificial);

(b) Average wetted width (cm, based on three cross sections);

(c) Dominant substrate type (sand/silt, gravels (2-64mm), cobbles (64-356mm), bedrock);

(d) Macrophyte coverage (0-25%, 25-50%, >50%);

(e) Shade (<10%, 10-30%, 30-50%, 50-70%, >70%)

(f) Floodplain connectivity (reduced by incision, restricted by modification, unrestricted); and

(g) Existing culverts (yes, no).

71. The One Plan adopts the RMA definition of a river, which includes *"continually or intermittently flowing body of fresh water"* but offers no further assessment criteria. This means that streams that flow for part of the year (intermittent streams) are considered to be watercourses by the One Plan and are treated the same as permanently flowing streams when it comes to assessing effects. In contrast, those that flow only immediately following rain (ephemeral streams) are not.

72. 'Continually and intermittently' flowing streams provide temporary or permanent habitat for aquatic fauna and contribute to various biotic and abiotic functions within a wider aquatic ecosystem. In contrast, ephemeral streams

[15] The current deign alignment largely has the same stream effects as those anticipated at 26a which is when stream walks commenced in September 2019.
[16] For the purposes of this assessment a reach is a length of stream with similar characteristics and ranges in length from ~10 m to 470 m.

tend to flow only after rain and provide a primarily overland flow path type function.

73. The One Plan does not provide specific definitions or an indication of how long the stream must flow to be considered 'intermittent' (rather than ephemeral). As such, stream reaches were classified as ephemeral, intermittent or permanent following the definitions within the Auckland Unitary Plan Operative in Part[17] ("**AUP OP**") (APPENDIX H.2: Auckland Unitary Plan Operative in Part - Definitions for Watercourses as applied to the Project.). The AUP OP provides clear direction as to the difference between ephemeral and intermittent streams and so was an appropriate definition to apply for the Project. This approach was also applied at the NoR stage.

74. Stream classifications were undertaken between the months of September to October, when stream flows are at their peak and consistent with the recommendations of Neale et al.[18] This means that the overlying definition ('intermittently or permanently flowing') can be more easily identified.

75. If at least one of the criteria listed under the AUP-OP 'intermittent' classification was identified, the potential stream was walked until its classification as either intermittent/permanent or ephemeral could be confidently determined.

76. Where three or more of the criteria were present and could be assessed with confidence,[19] a classification of intermittent was applied. If three criteria were not met, it was classified as ephemeral and was not mapped.

77. If the stream showed evidence of continual flow based on wetted width, water depth and position in catchment, it was classified as permanent. If this could not be confidently determined, the reach was classified as intermittent rather than permanent.

[17] Auckland Council, Auckland Unitary Plan Operative in Part (2016).
[18] Neale et al (n 3)
[19] For clarity, 'assessed with confidence' refers to the reliability of the individual criteria in the context of the site. For example, the criterion 'it has a well-defined channel, such that the bed and banks can be distinguished' could not be assessed with confidence where stock access had resulted in degradation to the channel. Similarly, if there was no upstream vegetation or source of flood debris, 'organic debris resulting from flood can be seen on the floodplain' could not be assessed with confidence.

78. Due to the modified nature of the landscape, the following additional criteria were applied when identifying streams:

(a) Where a farm pond was located online[20] of a stream, it was considered to be a modified watercourse and a stream line drawn through it.

(b) Where a clearly defined stream channel was observed in an otherwise wetland environment, both stream and wetland habitats were recorded.

(c) Where a wetland[21] was identified as being online of a stream but with no defined channel, the area was defined as a wetland only.

79. This detailed level of assessment was carried out within the immediate Project footprint, with the focus being on the directly impacted areas. Additional stream length outside of the directly impacted areas was estimated or predicted based on previous assessments, aerial photographs, overland flow paths and topographic maps, to provide further context to reporting.

Macroinvertebrates

80. Aquatic macroinvertebrate community structure, abundance and diversity are standard indicators of the long-term health of streams. Different taxa have varying tolerance of pollutants, so their presence or absence gives an indication of stream condition (being a combination of water and habitat quality).

81. A single macroinvertebrate sample was collected at each SEV site. Sites were classified as hard-bottom or soft-bottom based on the predominant substrate type present in the sampling reach. For sites where both soft-bottom and hard-bottom substrates were present, the sampling protocol was selected based on the habitat type most representative of the reach.[22]

82. Macroinvertebrate samples were collected using a kick net (D-shape, 0.5 mm mesh size). Sampling followed the semi-quantitative method for hard-bottom and soft-bottom streams (protocols C1 and C2 respectively).[22] Stable habitat features such as bank margins, woody debris and macrophyte were sampled in soft-bottom streams according to their occurrence in the reach. Riffle habitat was sampled in all hard-bottom streams.

---

[20] Where a pond is located 'in-stream', in that it is located in the path of the stream and has a clear inlet and outlet, it is referred to as being 'online' of the stream channel. Conversely, a pond located adjacent to or isolated from a stream channel, is 'offline'.

[21] For the purposes of this Project, wetlands were classified following the RMA definition and are assessed in the Technical Assessment F with terrestrial ecology.

[22] Stark et al (n 9).

83. Macroinvertebrate samples were preserved in ethanol prior to being sent to Stark Environmental Limited for taxonomic identification and processing. Samples were processed in accordance with Protocol P2 (200 fixed count and scan for rare taxa[22]).

84. The results reported include:

(a) **Taxonomic richness**. This is a measure of the number of different types of macroinvertebrate present in each sample and is a reflection of the diversity of the sample;

(b) **Ephemeroptera, Plecoptera and Trichoptera** ("**EPT"**) richness. This index measures the number of pollution-sensitive macroinvertebrates (mayfly, stonefly and caddisfly (excluding Oxyethira and Paroxyethira taxa because these are tolerant of degraded conditions)) within a sample. Percent EPT richness represents the number of EPT taxa as a proportion of the total number of taxa within the sample;

(c) **Macroinvertebrate Community Index** ("**MCI"**). The MCI is an index for assessing the quality class of a stream using presence or absence of macroinvertebrates. MCI is used for hard-bottom streams, while MCI-sb is for soft bottom streams; and

(d) **Semi/Quantitative Macroinvertebrate Community Index** ("**SQ/QMCI"**). QMCI is another index based tool, based on the relative abundance of taxa within a community, rather than just presence or absence. QMCI is used for hard-bottom streams, while QMCI-sb is for soft bottom streams. SQMCI is a semi-quantitative version of the index[23].

85. The MCI and SQ/QMCI reflect the sensitivity of the macroinvertebrate community to changes in water quality and habitat, where higher scores indicate better stream condition. Macroinvertebrate index values are then translated to quality classes, which describe the ecological health of the stream (Table H. 1).

[23] Results within this report are reported as QMCI however some data (collected during the NoR phase of work) were SQMCI. The relative ecological values remain the same irrespective of QMCI or SQMCI.

Table H. 1: Interpretation of macroinvertebrate biotic indices[24]

Quality class	MCI or MCI-sb	SQMCI & QMCI, SQMCI-sb & QMCI-sb
Excellent	>119	> 5.99
Good	100 - 119	5.00 – 5.90
Fair	80 - 99	4.00 – 4.90
Poor	<80	< 4.00

Fish

86. Building upon the fish survey undertaken in previous surveys in February and July 2018 (as reported in Technical Report 6C to the NoR process), a further six sites were surveyed for fish in November 2019.

87. Fish surveys were undertaken in all potentially affected catchments, excluding catchment 6 as the only area of the stream to be affected had very poor fish habitat. All fish survey locations are shown on Freshwater Ecosystem Drawings TAT-3-DG-E-4141 to 4147.

88. The fish survey method employed was in general accordance with the New Zealand Freshwater Fish Sampling Protocols for Wadeable Rivers and Streams.[25]

89. A combination of small fyke nets and gee minnow traps were left overnight (unbaited) and cleared the next morning at each site. Nets and traps were evenly distributed over a 150 m survey reach unless access was restricted due to shallow water.

90. Fish were identified, measured and then released into the same stream in which they were caught. The following variables were observed and recorded during fish assessments:

    (a) Species and size range; and

    (b) GPS location, weather conditions and stream characteristics.

91. Fish survey results were supplemented with NZFFD data and used to calculate the IBI [26] at each survey site (refer Table H.2). The fish IBI compares the fish community present with what might be expected considering the altitude of the

[24] Stark & Maxted (n 10).
[25] Joy, M, David, B, Lake, M (2013). New Zealand Freshwater Fish Sampling Protocols. Part 1: Wadeable Rivers and Streams. Massey University.
[26] Joy (n 12).

site and distance from the coast. It does not take into consideration presence of artificial or natural barriers to fish passage.

92. The IBI is a useful metric, however, it has some limitations in that it is intended for permanent streams. Many of the streams surveyed in the Project area are intermittent and therefore provide habitat for only part of the year.

Table H.2: Horizons Regional Council IBI scores[26]

Total IBI score	Integrity class	Attributes
68-100	Excellent	Comparable to the best situations without human disturbance; all regionally expected species for the stream position are present. Site is above the 80th percentile of Horizons sites
58-67	Good	Site is above the 60th percentile of all Horizons sites, species richness is slightly less than best for the region
46-57	Moderate	Site is above the 40th percentile of Horizons sites but species richness and habitat or migratory access reduced, some signs of stress
36-45	Poor	Site is less than average for Horizons region IBI scores, less than the 40th percentile, thus species richness and or habitat are severely impacted
1-35	Very poor	Site is below the 20th percentile meaning site is impacted or migratory access almost nonexistent
0	No native fish	Site is grossly impacted or access nonexistent

Stream ecological valuations

93. The SEV method was used to assess the aquatic ecological function of streams across the Project alignment using the methods described in Storey et al. (2011), Neale et al. (2011) and Neale et al. (2016).[27]

94. The SEV is a robust and internationally peer reviewed method designed to quantify the ecological function of a stream reach and, where all measures to avoid, remedy and mitigate effects have been exhausted, it provides a means to quantify offset requirements. The method has been applied in New Zealand for approximately 12 years to support resource consent applications, including

[27] Storey et al (n 2)
Neale M W, Storey R G, Rowe D K, Collier K J, Hatton C, Joy M K, Parkyn S M, Maxted J R, Moore S, Phillips N and Quinn J M (2011). Stream Ecological Valuation (SEV): A User's Guide. Auckland Council Guideline Document 2011/001.
Neale et al (n 3)

applications that have been heard at Council Hearings, Boards of Inquiry and at the Environment Court.[28]

95. The SEV method was originally developed for use in permanent streams, however, has recently been tested for intermittent streams in the Auckland Region.[29] The method has been determined to be appropriate to use on both stream type systems, with incorporation of stream specific criteria into the SEV calculators.

96. Fourteen variables are assessed and values assigned to four key ecological functions, as follows:

    (a) Hydraulic - assesses the flow regime, floodplain effectiveness and connectivity of the stream reach;

    (b) Biogeochemical - associated with the processing of pollutants, in-stream water chemistry and input and retention of organic matter;

    (c) Habitat provision - incorporates in-stream habitat for aquatic fauna and for fish spawning; and

    (d) Biodiversity provision - the level of intactness of fish fauna, invertebrate fauna and riparian vegetation.

97. The SEV results are reported on a scale of 0 to 1, where 1 is a pristine stream (i.e. native forest, non-modified) and values below this are a departure from these reference conditions. Each function is measured and compared to what would be expected in 'reference conditions' and the final score is an aggregation of weighted attributes that identifies how far from 'pristine' the stream reach is.

98. The SEV was developed for use in Auckland streams but has been successfully applied across New Zealand when local reference data has been incorporated into the SEV calculators. To date, Horizons has not formally developed a SEV calculator with local reference data. During the NoR phase of this Project, Horizons did however provide some reference data for inclusion in the SEV assessments.

[28] A recent example is the Transport Agency's proposed Mt Messenger Bypass Project, north of New Plymouth on SH3.
[29] Neale et al (n 3).

99. For the purposes of this assessment, the Auckland permanent and intermittent calculators have been modified to incorporate the previously supplied local reference data for the following variables:

(a) Vfish - Horizons IBI has been added and the algorithm modified.

(b) Vsurf - Horizons supplied data has been added.

(c) Vphyhab - Horizons supplied data has been added.

(d) Vept and Vinvert - Horizons data has been added and the algorithm modified.

100. The same reference data has been used for both intermittent and permanent streams, which is not a true reflection of the local reference conditions. However, I consider the reference data to be sufficiently robust to inform the assessment of ecological values and effects management of the Project.

101. Sites surveyed for the assessment were selected to be representative of the main stream types likely to be impacted and identified during site walkovers. A range of hard and soft- bottom, and highly and poorly shaded streams were selected as demonstrated by 'SEV Type' in Table H.3 below where:

(a) SEV Type 1 - Soft bottom (silt sand), >50% shade;

(b) SEV Type 2 - Soft bottom (silt sand), <50% shade;

(c) SEV Type 3 - Hard bottom (bedrock, gravel, cobble), >50% shade;

(d) SEV Type 4 - Hard bottom (bedrock, gravel, cobble), <50% shade.

102. Macroinvertebrate and fish data was collected as outlined in [81] and [87] and added into SEV calculators for the impact sites.[30]

103. Table H.3 below provides details of SEV surveys undertaken. The location of each SEV location (Reach ID) is shown on Freshwater Ecosystem Drawings TAT-3-DG-E-4141 to 4147.

Table H.3: SEV sites within the alignment.

Date	Reach ID	Stream Type	Stream Classification	SEV reach length (m)	SEV Type
6/11/2019	SEV1A	SB	Permanent	100	2
9/09/2019	SEV2B1	SB	Permanent	100	2
9/09/2019	SEV2C	HB	Intermittent	100	3
9/09/2019	SEV2C2	SB	Permanent	100	2

[30] Macroinvertebrate and fish data has not been collected at offset sites because this data is not included in the calculation of ecological compensation ratios (ECR) used to determine offset requirements. This is consistent with the method.

Date	Reach ID	Stream Type	Stream Classification	SEV reach length (m)	SEV Type
10/09/2019	SEV2C8	Mix	Intermittent	100	1
9/09/2019	SEV2E	SB	Permanent	100	2
9/09/2019	SEV2E2	SB	Intermittent	100	2
10/09/2019	SEV3A	SB	Permanent	100	2
10/09/2019	SEV3B	Mix (HB)	Intermittent	100	3
11/09/2019	SEV4A	SB	Permanent	100	2
27/09/2019	SEV4A 3 + 4	HB	Permanent	100	4
11/09/2019	SEV4D	HB	Permanent	100	4
11/09/2019	SEV4C1	SB	Intermittent	100	2
11/09/2019	SEV4F	SB	Intermittent	100	2
26/09/2019	SEV5A9	SB	Permanent	100	1
26/09/2019	SEV5Aa u/s	HB	Permanent	100	4
26/09/2019	SEV5Ab d/s	HB	Permanent	70	3
26/09/2019	SEV5B6	HB	Permanent	100	4
26/09/2019	SEV5B7	SB	Intermittent	100	2
26/09/2019	SEV5B9	HB	Intermittent	100	3
25/09/2019	SEV7A1	Mix (SB)	Intermittent	70	3
25/09/2019	SEV7A2	SB	Intermittent	65	2
24/09/2019	SEV7B	SB	Permanent	60	2
24/09/2019	SEV7B 1 +2	SB	Intermittent	100	2
24/09/2019	SEV7B0	HB	Permanent	100	3
27/09/2019	SEV8A1	SB	Intermittent	100	2

Offset methodology

104. In order to define the quantum of stream enhancement and/or restoration required to address the residual adverse effects on freshwater stream systems, environmental compensation ratios[31] ("**ECR**") have been calculated where stream habitat loss or modification occurs. The ECR quantifies the likely loss in values and functions at an impact site and the increase in stream ecological values and functions at an enhancement[32] site.

105. It is difficult to remediate or mitigate[33] the effects on the stream at the point of impact as for the majority of the affected reaches, the natural stream channels will be infilled and a new channel constructed elsewhere. Where remediation

[31] Storey et al (n 2).
[32] From an ecological point of view, the SEV and ECR method provide a means to measure the ecological loss (at an impact site) and ecological gain (at an enhancement site). Whether this enhancement contributes to remediation, mitigation, offset or compensation is for consideration in the assessment of effects, not in the quantification process.
[33] To 'mitigate' means to alleviate or moderate the severity of something (Maseyk et al. 2018) which is not possible when the natural channel no longer exists as a result of the complete and permanent loss of habitat at the point of impact.

or mitigation is not possible, offsetting is the next step in the mitigation hierarchy.

106. The SEV (and ECR)[34] is recognised as being a robust and effective tool to support offsetting decision making for freshwater stream systems.[35] Specifically, it provides a transparent framework to determine whether 'no net loss' can or will be achieved. It does not however address all principles of offsetting, nor should it be a 'one stop shop' to circumvent the mitigation hierarchy.

107. The ECR determines the amount of streambed area that is required to be restored, depending on the extent and type of enhancement works proposed, relative to the amount lost to achieve a 'no-net-loss' in ecological function as a result of the activities.

108. The ECR formula (shown in Table H.4) requires a SEV score to be calculated for both the impact ('I') and proposed mitigation ('m') sites. In practice, the 'm' refers to measures that could be considered remediation, mitigation, offset or compensation. This ECR formula provides a basis from which to quantify and scale the likely loss in values and functions at an impact site and the increase in stream value and functions at an enhancement site.

109. The formula compares the loss in ecological value at the impact site (SEVi-P - SEVi-I) to the gain in ecological value at the mitigation site (SEVm-P - SEVm-C), and includes a multiplication factor (1.5) to account for the time lag before enhancement at the mitigation site is achieved. The 'gain' part of the equation could include activities that meet the intent of remediation, mitigation, offset or compensation. For simplicity, the words 'loss' and 'gain' are used to describe the two parts of the equation within this assessment.

[34] The ECR formula includes reference to terminology used in planning such as 'compensation' and 'mitigation'. It is important to note that while the name ECR includes 'compensation' the outcomes is in fact a quantum of enhancement required to achieve no net loss and can therefore be considered 'offsetting' or mitigation depending on the proposed enhancement activity. Mitigation as referred to in the formula, could comprise remediation, mitigation, offsetting or compensation activities.

[35] Maseyk, F, Ussher, G, Kessels, G, Christensen, M, and Brown, M (2018). Biodiversity offsetting under the Resource Management Act – A guidance document September 2018.

Table H.4: ECR formula and restoration formula[36]

ECR = [(SEVi-P – SEVi-I) / (SEVm-P – SEVm-C)] × 1.5 Where:[37] **SEVi-P** is the potential SEV value for the site to be impacted. **SEVi-I** is the predicted SEV value for the stream to be impacted after impact. **SEVm-C** is the current SEV value for the site where environmental offset is applied. **SEVm-P** is the potential SEV value for the site where environmental offset is applied. The '1.5' included in the formula is a standard multiplier assigned to the formula to account for time lags associated with enhancement measures being realised. For instance, to account for delays with plant establishment. Restoration formula: *Restoration stream length required = (impact area × ECR) / restoration channel width*

110. A representative SEVi-I and SEVi-P has been assigned to all stream reaches affected by the Project based on proximity to field survey locations and similar characteristics. That is, there are 194 impact reaches with corresponding SEVi-I and SEVi-P values.

111. SEVi-I scores have been assigned based on two proposed 'loss' scenarios:

(a) The SEV method is not intended for application within culverts and so the impact score should not be 'modelled' for each culvert. Rather a SEVi-I value has been assigned which reflects the limited ecological function that the culvert retains including provision of flowing water, catchment connectivity, shade and hard substrate. An SEVi-I has been applied to culverts that will be located online[38] of a stream based on two scenarios. Culverts with a gradient of <6% were assigned 0.23 while steeper culverts with grade >6% were assigned 0.15.[39]

(b) An SEVi-I of 0 has been applied to all remaining stream length which is not being culverted and is instead being infilled.[40] From an ecological standpoint a score of 0 is appropriate because (following impact) the

[36] Storey et al (n 2).

[37] Note that the SEV scores used in the ECR calculator do not include the fish and invertebrate (V_{FFI} and V_{IFI}) variables as the fauna values are difficult to predict and is consistent with the method.

[38] Where culverts will have no headwater flows or will not be located on a stream path following construction, they are assigned an impact value of 0.

[39] These values are consistent with SEV values assigned to culverts in the recent Mt Messenger project.

[40] Much of the stream length being infilled is being replaced by constructed stream diversions. As the impact should be assessed at the point of impact, I consider that the SEVi-I value is taken from the bed of the stream that exists prior to works commencing. The diversions then contribute to the other side of the ECR ledger, being the 'mitigation' ('m')component.

streambed habitat will be filled in, will no longer function as a stream and will cease to exist.

112. Stream diversions are considered to contribute to 'gains' resulting from the project. SEVm-C and SEVm-P scores have been assigned to proposed stream diversions based on modelled SEV scores to reflect the relative ecological function and value those diversions will provide.

(a) An SEVm-C score of 0 has been assigned for the 'pre-construction' state of diversions, as the diversions will be cut into ground.

(b) SEVm-P scores have been modelled for each of the proposed stream diversions based on some key criteria expected to influence the post-construction score:

(i) Composition of riparian margin and anticipated height (with an assumption that height of riparian planting will be restricted within Te Āpiti Wind Farm to 1.5 m, based on Designation Condition 19. a) ii) B);

(ii) Proximity to road or wetland which will limit riparian margin width;

(iii) Connectivity to upstream habitat or unimpacted headwater stream;

(iv) Vertical realignment into engineered material, or diversion into natural ground; and

(v) Whether the constructed channel will be low lying or steeply graded and consequently its habitat values.

113. For residual effects that cannot be addressed by the stream diversions, it is proposed to undertake riparian enhancement and restoration (including planting) at an alternative site to contribute to offsetting. For SEV and ECR modelling, in the order of 23 km of stream length potentially available for enhancement was identified at a nearby farm, Ratahiwi farm, run by Horizons Farm Limited ("**Ratahiwi**") (described further below). In this assessment, Ratahiwi farm has been used as an indicative target location for the riparian planting. It is expected that other sites will ultimately also be utilised to complete the offset package, including because as discussed below it is likely that not all 23 km of the modelled stream length at Ratahiwi Farm will be available. Ecological gains modelled at the Ratahiwi site are considered to be representative of the gains that could be obtained at other sites within proximity of the Project.

114. For the Ratahiwi stream sites:

(a) SEVm-C scores have been determined by field survey at representative sites within the Ratahiwi stream sites.

(b) SEVm-P scores have been modelled based on the proposed enhancement measures at Ratahiwi stream sites including 20 m riparian planting and stock exclusion fencing.

115. For each of the 194 impact reaches a corresponding offset reach has been identified to provide a 'loss' to 'gain' specific ECR and corresponding offset amount to achieve no net loss.

116. Assumptions associated with all modelled SEV values are included as APPENDIX H.3: Assumptions associated with SEV calculations.

AQUATIC VALUES

Stream classifications and state of streams

117. Across the alignment, 194 reaches (sections) of stream have been assessed over nine catchments (refer to Figure H.1, and Freshwater Ecosystem Drawings TAT-3-DG-E-4141 to 4147). For the most part, the streams have been subject to some agricultural land use and consequently have degraded riparian margins and stream banks resulting from stock access and inputs of nutrients and fine sediments.

118. Many of the headwaters had narrow, shallow channels, dominated by cobble substrates. Fine sediments were present. These headwater reaches were typically classified as intermittent reaches and were steep.

119. Over half of the stream length surveyed had less than 50% shade and silt and sand was the dominant substrate. In many instances, this was due to fine sediment deposition within a naturally hard bottom stream.

120. Approximately 10% of the stream length surveyed had greater than 50% shade. This reflects the predominantly agricultural land use the alignment is proposed to transect.

121. Channel incision was present in approximately one-third of the stream reaches surveyed. This is expected to be linked to the lack of intact riparian margins and stock access.

122. The lower reaches of catchments 3, 4, 5, and 6 are within the MGSR along the Gorge. These reaches were not specifically assessed for this Project as they are outside of the Project area, however were observed to be more natural in character.

123. Catchments 6 and 7 and a small part of catchment 4 are located within areas subject to QEII Open Space Covenants. The stream channels within the vegetated, fenced areas were of notably higher quality than the stream reaches outside of fenced areas.

124. Catchments 1 and 8 were markedly different than the other streams, due to the nature and degree of modification and the characteristics of the habitats. These catchments had highly modified, with straightened and deepened channels with evidence of channel clearance. The dominant substrates were fine sediments and macrophytes were present.

Fish

125. Fish surveys were undertaken to inform presence/absence in the reaches most likely to be affected by the project. Survey results and the associated IBI are provided in Table H.5 below.[41]

126. A total of 14 species have been recorded within the Manawatū catchment (NZFFD), and of these five were recorded during fish surveys for this Project.

127. Of the species identified during this project, only the longfin eel is threatened, with a classification of At Risk - Declining.[42] This means that while the species is not currently threatened and may appear to be common, the population is declining. Some of the documented threats to longfin eels include habitat modification and loss, fish passage barriers and commercial fishing.[43]

128. Non-diadromous species, such as upland bullies, are present within Catchment 4. This means that the fish do not migrate as part of their lifecycle. They are present in an area which is likely to be desirable habitat and they do not typically move to other areas.

---

[41] Fishing was not undertaken within Catchment 6.
[42] Dunn, NR, Allibone, RM, Closs, GP, Crow, SK, David, BO, Goodman, JM, Griffiths, M, Jack, DC, Ling, N, Waters, JM, and Rolfe, JR (2018). Conservation status of New Zealand freshwater fish, 2017. New Zealand Threat Classification Series 24. Wellington: Department of Conservation. Retrieved from www.doc.govt.nz.
[43] https://www.doc.govt.nz/nature/conservation-status/

129. The upper catchments along much of the alignment have stock access and are intermittent in nature, thus reducing the quantity of available, suitable habitat for many native species.

130. Catchments 2 to 7 are very steep and are close to 300 metres above sea level (m.a.s.l) in the headwaters. While comprehensive surveys of the lower reaches have not been undertaken, waterfalls and steep chutes have been observed during field work and these natural barriers will influence fish presence within the upper reaches. Further, the presence of culverts along the railway line through the Manawatū Gorge are expected to be at least partial barriers to fish passage.

131. Based on the information gained to date, it is considered that the fish diversity within the Project area is highest in the Manawatū River and Mangamanaia Stream. Most of the catchments have a much lower fish diversity in the headwaters, which is likely to be due to the available habitat and restricted access by natural and artificial barriers to passage.

Table H.5: Summary fish data reported as present or absent on a sub catchment basis. IBI is provided.

Common name	Scientific name	Threat status**	NZFFD (Manawatū)	Catchment results							
				1	**2 (2C)**	**3**	**4**	**5**	**7**	**8**	**9**
Shortfin eel	*Anguilla australis*	Not threatened	Y	Y	Y	Y	Y		Y	Y	Y
Longfin eel	*Anguilla dieffenbachii*	At risk - declining	Y		Y	Y		Y	Y		
Torrentfish	*Cheimarrichthys fosteri*	At risk - declining	Y								
Dwarf galaxias	*Galaxias divergens*	At risk - declining	Y								
Upland bully	*Gobiomorphus breviceps*	Not threatened	Y				Y				
Common bully	*Gobiomorphus cotidianus*	Not threatened	Y		Y					Y	Y
Redfin bully	*Gobiomorphus huttoni*	Not threatened	Y		Y						
Unknown bully	*Gobiomorphus* spp.	N/A	N				Y			Y	Y
Brown mudfish	*Neochanna apoda*	At risk - declining	Y								
Koura	*Paranephrops* spp.	Not threatened*	Y								
Perch	*Perca fluviatilis*	Introduced and naturalised	Y								
Common smelt	*retropinna retropinna*	Not threatened	Y								
Unidentified salmonid	*Salmo* spp.	N/A	Y								
Brown trout	*Salmo trutta*	Introduced and naturalised	Y								
	Horizons IBI value		**78**	**24**	**70 (24)**	**52**	**34**	**48**	**54**	**42**	**52**
	Horizons IBI descriptor		**Excellent**	**Very Poor**	**Excellent (Poor)**	**Moderate**	**Very Poor**	**Moderate**	**Moderate**	**Poor**	**Moderate**

Macroinvertebrates

132. Macroinvertebrate results across the alignment vary in response to the dominant land use and presence of riparian margins.

133. Results are presented in Table H.6 and Table H.7, and MCI and SQ/QMCI results are shown on Figure H.2 and Figure H.3 below.

134. The SQ/QMCI considers the relative abundance of the species recorded, whereas the MCI only considers presence vs absence. This means that the SQ/QMCI is more reflective of the dominant species present and is less reactive to rare species, which the MCI is.

135. For the most part, macroinvertebrates from within the proposed alignment were indicative of poor to fair water and habitat quality (being scores of less than 100 or 4.90, refer Table H. 1). This was evident at sites where riparian margins were absent, streams were low lying and margins were impacted by agricultural land use.

136. The highest MCI and SQ/QMCI scores were recorded from within reaches dominated by relatively intact riparian margins and cobble stream systems.

137. The upper reaches of catchment 5B had surprisingly high macroinvertebrate indices given the land use and modification of riparian margins. It is expected that the steep, incised channels provide protection from stock access and hard bottom substrates provide suitable habitat for fauna.

138. The results are comparable to the results obtained at the NoR stage (reported in Table H.6 and Table H.7 and shown on Figure H.2 and Figure H.3 below). It is expected that sample location being primarily in vegetated areas and time of year are the likely contributors to the small levels of variation seen within sample results.

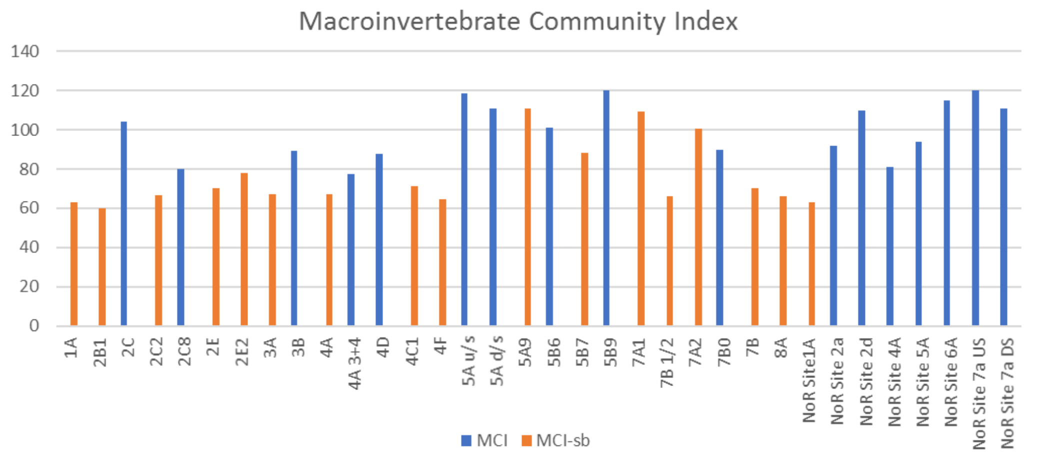


Figure H.2. ***MCI results at each of 26 SEV sites representative of impact sites. NoR results representative of wider environment.***

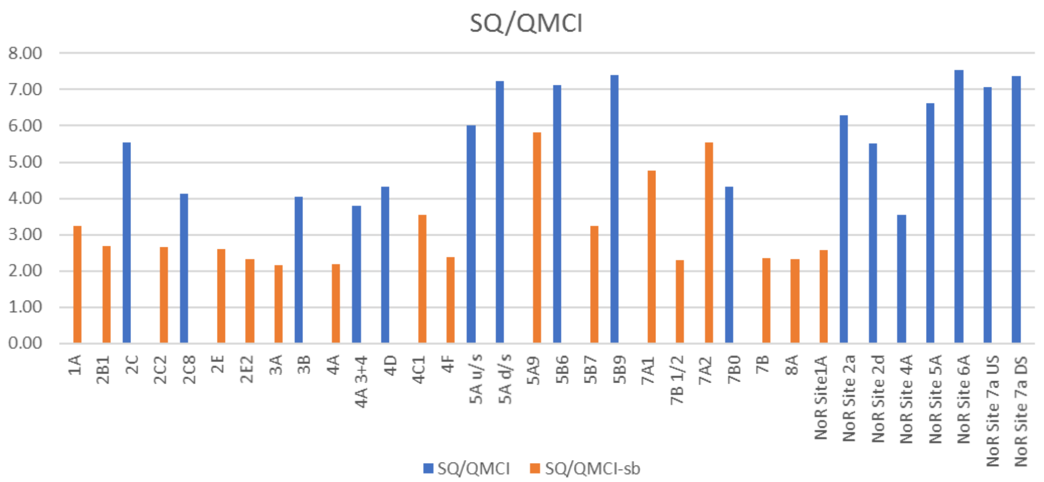


Figure H.3. ***SQ and QMCI results at each of 26 SEV sites representative of impact sites. NoR results representative of wider environment.***

Table H.6: Macroinvertebrate results from NoR investigations.[44]

Sampling site	Macroinvertebrate parameter				
	Taxonomic richness	No. of EPT taxa	Percent EPT abundance	MCI	SQMCI
1A	13	1	7.7	63	2.58
2A	19	8	42.1	92	6.29
2D	9	2	22.2	110	5.52
4A	21	5	23.8	81	3.54
5A	17	5	29.4	94	6.63
6A	17	7	41.2	115	7.55
7A US	9	4	44.4	120	7.06
7A DS	20	6	30.0	111	7.38

[44] Technical Report 6C (n 4).

Table H.7: Summary of macroinvertebrate community results from SEV surveys.

Site	Dominant substrate	Number of taxa (incl. rare taxa)	Number of rare taxa	Number of individuals*	Percentage counted	%EPT richness*	%EPT abundance*	MCI	QMCI	MCI-sb	QMCI-sb
1A	SB	19	7	223	10	0.00	0.00			63	3.24
2B1	SB	17	0	204	90	5.88	1.96			60	2.69
2C	HB	20	0	219	100	25.00	32.88	104	5.54		
2C2	SB	20	1	211	50	10.00	7.11			67	2.66
2C8	HB	16	0	130	100	6.25	2.31	80	4.12		
2E	SB	18	1	217	30	5.56	0.46			70	2.61
2E2	SB	12	0	217	25	0.00	0.00			78	2.34
3A	SB	14	2	203	25	14.29	0.99			67	2.15
3B	HB	19	0	115	100	10.53	7.83	89	4.03		
4A	SB	11	7	215	10	18.18	0.93			67	2.19
4A 3+4	HB	16	0	220	30	12.50	8.64	78	3.80		
4D	HB	15	2	204	25	20.00	4.41	88	4.32		
4C1	SB	12	0	207	80	0.00	0.00			72	3.55
4F	SB	10	0	248	75	0.00	0.00			64	2.38
5A u/s	HB	15	3	208	35	46.67	50.00	119	6.00		
5A d/s	HB	22	2	209	40	36.36	80.38	111	7.24		
5A9	SB	11	0	211	85	18.18	27.01			111	5.82
5B6	HB	17	0	202	100	35.29	81.19	101	7.13		
5B7	SB	14	0	119	100	0.00	0.00			88	3.23
5B9	HB	12	0	206	33.3	58.33	88.35	120	7.40		
7A1	SB	19	1	228	50	15.79	1.75			109	4.76
7B 1/2	SB	12	2	219	60	8.33	0.46			66	2.29
7A2	SB	11	0	45	100	9.09	4.44			101	5.54
7B0	HB	25	0	212	100	16.00	15.09	90	4.32		
7B	SB	27	6	256	10	3.70	0.78			70	2.36
8A	SB	22	12	213	2.5	0.00	0.00			66	2.31

*based on a 200 fixed count with scan for rare taxa**excl. Hydroptilidae

Stream ecological valuations

139. SEV scores across the alignment ranged from 0.29 to 0.79, as shown in Table H.8. The scores shown include an overall SEV value as well as scores for each of the four key ecological functions.

140. On average, the hydraulic function and biogeochemical functions scored the highest, reflecting good connectivity with groundwater, limited barriers to passage (within the assessment reach) and minimal channel modifications (i.e. lining). Variables such as shade were notably absent in some reaches, and this influenced biogeochemical function scores.

141. Habitat provision and biodiversity functions were notably lower, driven by limited riparian margins, generally poor diversity of fish and poor macroinvertebrate community indices.

142. **Catchments 1 and 8** had the lowest SEV scores, reflecting a high level of modification and poor ecological function. Several reaches within **catchment 2** showed similar characteristics, however the upper 2C catchment had restricted stock access, shading and habitat heterogeneity and so was markedly better than other reaches within the catchment.

143. Reaches within **Catchments 3 and 4** had an overall moderate SEV value, ranging from 0.38 to 0.66. Lack of riparian margins, evidence of habitat modification and poor biodiversity values influenced these scores.

144. On a whole of catchment basis, **Catchment 5** had the highest average SEV score despite there being areas of stock access and a paucity of riparian vegetation. For the most part, stream reaches were protected from stock (either via vegetation or steep grades) and in-stream habitat features were varied. Shade was provided by steep banks or for many parts of the catchment, riparian margins. Macroinvertebrate communities were indicative of good and excellent water and habitat quality, influencing the biodiversity function scores.

145. **Catchment 7** comprises three main sub-catchments, and a clear difference was observed in SEV scores between those surveyed. Sub-catchment 7A had a higher ecological value on average than sub-catchment 7B, driven primarily by presence of riparian margins, stock access and shade.

146. Eight SEV were previously undertaken across the Project to inform the NoR process.[45] SEV scores ranged from 0.38 to 0.86. SEV scores from within Catchment 2D, 7A (upstream) and 6A were over 0.80 and the highest obtained across the Project. These are reflective of a high level of ecological function driven by intact riparian margins and stock exclusion. Those scores are from locations that are outside of the proposed Project footprint.

147. I consider that the scores obtained across the Project alignment are typical of rural land use, albeit some in better condition than others. I consider none of the SEV scores obtained within the Project footprint to be representative of reference conditions or those that might be obtained within a predominantly native catchment.

Table H.8: Summary of stream ecological valuation results shown per function and overall.

Sub catchment	Site name	Hydraulic function	Biogeochemical function	Habitat provision function	Biodiversity function	Overall SEV score[46]
1	SEV1A	0.49	0.32	0.22	0.17	0.32
2	SEV2B1	0.49	0.25	0.19	0.16	0.29
	SEV2C	0.86	0.79	0.44	0.51	0.70
	SEV2C2	0.68	0.36	0.21	0.23	0.40
	SEV2C8	0.93	0.92	0.63	0.49	0.79
	SEV2E	0.71	0.37	0.22	0.23	0.41
	SEV2E2	0.71	0.48	0.28	0.30	0.47
3	SEV3A	0.57	0.35	0.20	0.31	0.38
	SEV3B	0.79	0.74	0.47	0.47	0.66
4	SEV4A	0.75	0.58	0.31	0.29	0.53
	SEV4A 3 + 4	0.58	0.43	0.61	0.25	0.46
	SEV4D	0.80	0.56	0.51	0.27	0.56
	SEV4C1	0.76	0.61	0.23	0.29	0.53
	SEV4F	0.67	0.34	0.20	0.26	0.40
5	SEV5A9	0.88	0.90	0.50	0.54	0.76
	SEV5Aa u/s	0.70	0.56	0.56	0.39	0.56
	SEV5Ab d/s	0.79	0.80	0.64	0.45	0.70
	SEV5B6	0.67	0.51	0.52	0.32	0.52
	SEV5B7	0.68	0.53	0.30	0.33	0.50
	SEV5B9	0.73	0.73	0.58	0.50	0.66
7	SEV7A1	0.84	0.94	0.49	0.60	0.78
	SEV7A2	0.63	0.56	0.28	0.40	0.50
	SEV7B	0.66	0.39	0.29	0.32	0.44
	SEV7B 1 +2	0.69	0.44	0.31	0.35	0.47

[45] Technical Report 6C (n 4).
[46] Consistent with the SEV method, the SEV values here include the variables FFI and IFI, being fish fauna intact and invertebrate fauna intact. SEV values included in the ECR (and presented later in this assessment) exclude these values as they are more difficult to model and predict in response to environmental enhancement.

Sub catchment	Site name	Hydraulic function	Biogeochemical function	Habitat provision function	Biodiversity function	Overall SEV score[46]
	SEV7B0	0.83	0.84	0.44	0.45	0.70
8	SEV8A1	0.48	0.24	0.19	0.27	0.31

Summary of ecological values

148. Most of the stream catchments are short and steep, with unvegetated headwaters, modified through agricultural land use. The lower reaches of these catchments are within the MGSR and of markedly higher quality. QEII Open Space Covenants over areas of bush within catchment 7, 6 and 4 are also of high quality and effects are, for the most part, avoided.

149. Catchments 1 and 8 are highly modified through agricultural land use and the ecological values reflect this degradation. Catchment 5 is of surprisingly good quality reflected in good SEV scores and macroinvertebrate indices.

150. Much of the Project footprint interacts with highly modified, degraded stream systems, however there are isolated areas of better aquatic values.

151. This section has provided an overview of the results of field surveys undertaken to inform the regional consenting process. The level of ecological value for each catchment and affected habitat/fauna is provided within the Assessment of Effects section of this assessment with reference to the level of value within Table H.19 in APPENDIX H.1: Ecological Impact Assessment Guidelines.

STATUTORY CONSIDERATIONS

One Plan

152. Schedule A of the One Plan identifies the Project as being located within the Surface Water Management Zones ("**SWMZ**") Middle Manawatū (Mana_10) and Upper Gorge Catchments (Mana_9) Water Management Zone within the Parent Catchment: Manawatū. The streams affected by the Project fall within the following water management sub-zones:

    (a) Middle Manawatū Mana_10a (Manawatū River in Gorge and catchments 3, 4, 5, 6, 7, 8);

    (b) Middle Manawatū Mana_10d (Catchment9, Pohangina River); and

    (c) Upper Gorge Mana_9c (Mangaatua River and catchments 1, 2).

(d) Schedule B of the One Plan identifies the following SWMZ Values that Sub-catchment Mana 10a and Mana_10d are Sites of Significance in respect to both riparian and cultural values as well as being of trout fishery ('other') value.

(e) In addition, the following Surface Water Management Values apply to all SWMZ's:

(i) Ecosystem values Life-supporting capacity ("**LSC**"). All relevant sub-zones are classified as Hill Mixed LSC.

(ii) Social/economic values Capacity to Assimilate Pollution ("**CAP**").

(iii) Additional values that apply but are not specifically related to this assessment include Recreational and cultural values including Contact Recreation ("**CR**"), Mauri ("**Mau**") and Aesthetics ("**Ae**").

153. Schedule E of the One Plan specifies Surface Water Quality Targets for rivers within the Manawatū Region. Table E.1 identifies targets for all rivers and Table E.2 specific targets for different Water Management Sub-Zones ("**WMSZ**").

154. The targets relevant to this freshwater ecology assessment are shown in Table H.9. Refer to Technical Assessment C (Water Quality) for additional commentary regarding water quality targets.

Table H.9: Ecological targets from Tables E.1 and E2 of the One Plan.

Relevant WMSZ	MCI	Deposited sediment cover(%)[47]	Protection level[48]	Periphyton Filamentous Cover	% change in QMCI[49]
All WMSZ	N/A	N/A	N/A	30%	20
Upper Gorge Mana_9c	100	<20	95%	N/A	N/A
Middle Manawatū Mana_10a	100	<20	95%	N/A	N/A
Middle Manawatū Mana_10d	100	<20	95%	N/A	N/A

[47] Only applies for State of the Environment monitoring to determine if the percentage over of deposited sediment on the bed of the river will provide for and maintain the values in each WMSZ.
[48] The ANZG guidelines set Default Guideline Values (DGVs) to protect freshwater systems. A 95% protection level is appropriate for moderately disturbed ecosystems such as those within the Project area.
[49] This target is only relevant when measuring the percentage change following a change in the environment. For instance, it would be useful to apply to similar habitats upstream and downstream of a discharge to measure potential effects.

NPS-FM water quality attributes

155. One of the key objectives of the National Policy Statement for Freshwater Management[50] ("**NPS-FM**") is to '*safeguard the life-supporting capacity, ecosystem processes and indigenous species including their associated ecosystems, of fresh water*'. The NPS-FM provides a National Objectives Framework ("**NOF**") which sets compulsory national values to protect freshwater 'ecosystem health'. NOF for river ecosystem health include periphyton, nitrate, ammonia and dissolved oxygen (below point sources).

156. Refer to Technical Assessment C (Water Quality) for an assessment of these attributes in relation to water quality for this Project.

Offsetting under the Resource Management Act (1991) and the One Plan

157. The purpose of the RMA is to promote the sustainable management of natural and physical resources, while avoiding, remedying or mitigating adverse effects on the environment. There are some instances where adverse effects cannot be mitigated and offsetting or compensation may be appropriate to address residual, significant adverse effects. The RMA requires decision-makers to consider offset / compensation measures proposed by applicants when determining consent applications.

158. The One Plan objectives and policies identify that offsetting can balance residual significant adverse effects and provides specific direction in relation to terrestrial habitats. Policy 19-1 identifies that financial contributions can be offered to 'offset' adverse effects on aquatic ecosystems and rivers where the financial contribution provides for restoration or enhancement of aquatic ecosystems. No further guidance is provided for offsetting effects on freshwater systems; what is proposed in this assessment is much more closely related to addressing the effects of the Project than a financial contribution.

159. Biodiversity Offsetting Under the Resource Management Act 2018[51] (hereafter "**BOURMA**") is the most recent national guideline that draws from international and national guidance on offsetting and compensation. BOURMA sets out that the following principles are key to differentiating between an offset and compensation (which is not required to demonstrate a no-net-loss outcome):

(a) Limits to offsetting - many biodiversity values are not able to be replaced because of their inherent irreplaceability or vulnerability. They

[50] New Zealand Government – National Policy Statement Freshwater Management (2017).
[51] Maysek et al (n 35).

may also be of such a high value that biodiversity gains cannot account for the residual effects;

(b) No-net-loss and preferably a net gain - this requires that at a specified point in time, biodiversity values will be returned to the point they were prior to the impact occurring. This is a measurable outcome and requires that a robust and transparent accounting process is adhered to;

(c) Landscape context - the biodiversity offset should consider the wider landscape context and recognise the temporal and spatial interactions between species, habitats and whole ecosystems;

(d) Additionality - the proposed offset needs to be additional to what would be achieved without the offset being applied;

(e) Permanence - the outcomes of the proposed offset needs to be secured for the length of time the effect exists for and preferably in perpetuity for permanent effects;

(f) Ecological equivalence - the measurement and balance of biodiversity losses and gains between the impact and offset sites resulting in a no-net-loss for the proposed biodiversity exchange. This requires that the offset values are 'like for like' with the impact values;

(g) Adherence to the mitigation hierarchy - offsetting must only be applied, after all other measures to avoid, remedy or mitigate effects have been exhausted;

(h) Stakeholder participation - offsetting should not occur in isolation and rather should involve engagement and collaboration with key stakeholders to determine, evaluate, select, design, implement and monitor offsets;

(i) Transparency - of biodiversity exchange, offset methodology and evaluation;

(j) Science and traditional knowledge - offsets should be informed by science and traditional knowledge; and

(k) Equity - sharing the rights, responsibilities, risks and rewards of an offset respecting legal and customary arrangements.

160. I discuss these principles later in this report, in respect of the proposed measures to address stream habitat loss effects.

PROJECT SHAPING AND AVOIDING AND MINIMISING EFFECTS

161. This section provides an overview of specific measures implemented to avoid or minimise freshwater ecology effects from a whole of Project point of view, and processes followed to achieve informed decisions on matters relating to freshwater ecology effects. A more detailed assessment of this is provided within Chapter 7 of the AEE.

Northern Alignment

162. The proposed alignment was changed, following the confirmation of the NoRs by the Transport Agency, to avoid or minimise effects on areas of high ecological value. This 'Northern Alignment' reduces the effects assumed at the initial NoR stage. In terms of freshwater ecology effects on catchments 7 and 6 have been reduced.

163. A maximum extent of 7A and 6A stream loss within areas subject to QEII Open Space Covenants and shown on Drawing C-10 (of the NoR application) was specified in the Designation Conditions and the proposed alignment results in less loss than that maximum.

Spoil site selection

164. The DCR includes a discussion of the Project spoil sites, and the process for selecting those sites (refer Appendix C of the DCR). Gullies were identified as being the most appropriate position for spoil sites given the need for large filling volumes. Several phases of site selection were undertaken to reach the final decision, including consideration of ecological impacts. Specific ecological factors included:

    (a) Extent and type of ecological area impacted;

    (b) Stream connectivity;

    (c) An expectation that upper catchment areas would have a lower value than further down;

    (d) Preference of one larger impact area, rather than several smaller areas; and

    (e) Protect opportunities for enhancement within the Project area.

165. Spoil sites 25 and 8 were discussed in the most detail, following field surveys revealing that the upper catchment 5 was of reasonably high ecological value. An assessment of the combined freshwater and terrestrial ecological values

was undertaken to determine the magnitude of effect between the two options. Spoil site 8 would have resulted in marginally less (150 m) stream length impact than Spoil site 25, but would have impacted more stream bed area given the wider stream reaches. Maintaining (fish passage) connectivity with the habitat upstream of the Project, if Spoil site 8 was in place, would be very challenging due to grades therefore reducing the potential habitat value of the stream under Spoil site 25. For these reasons, Spoil site 25 was recommended over Spoil site 8 in relation to freshwater ecology values.

Bridges and culverts

166. Bridges were implemented at several sites to minimise the potential modification of streams and their margins, as discussed in the DCR. Notably this includes BR03 (Eco Bridge over high value raupō wetland within Catchment 7) and BR07 (Mangamanaia Stream Bridge).

167. The intention was to provide fish passage at all culverts along the alignment however in some places, to achieve the desired grade, a longer culvert that would have additional stream habitat effects would be required. Discussions where held between engineers and ecologists to identify areas of highest fish passage value and those areas where the residual habitat following construction would not be sufficient to warrant passage. Consideration was also made to the permanence and area of habitat upstream of the culverts. Fish passage provision is discussed in more detail below.

ASSESSMENT OF EFFECTS

Overview of effects

168. This section provides an overview of freshwater ecology effects from a whole of Project point of view. A more detailed assessment of each of these effects at a catchment scale is included in the sections following.

169. The potential effects on freshwater ecology resulting from the Project have been assessed in terms of short- and long-term effects.

170. Short term effects relate to the effects within the construction phase which could include fish injury and/or mortality, and water quality effects resulting from sedimentation and cut vegetation storage. Potential long-term (operational) effects anticipated to occur from the Project include reduced fish passage, water quality effects, changes to hydrology, and modification and loss of stream ecological function and habitat area.

171. In respect of the EcIAG described in [57 to 62], this section presents an overview of the pre- and post-mitigation magnitude of effect for each activity. The magnitude of effect from different activity types is summarised in Table H.10 using the approach described in [60] above.

172. The level of effect (which combines ecological value and magnitude of effect) was used to guide the extent and nature of the ecological management response recommended, which in this case includes remediation, mitigation, and offsetting.

173. The following sections include the ecological value of each catchment, the magnitude of effect following mitigation measures being implemented and finally an overall level of effect.

Short-term effects – during construction

174. Native freshwater fauna are present in low numbers across the Project footprint and include longfin eel which are an 'At risk - Declining' species. There is high potential for injury or mortality of native freshwater fauna during construction of diversions, installation of culverts and dewatering of streams in the absence of any controls. Implementation of fish salvage and relocation protocols will reduce the magnitude of effect to Low.

175. A discharge of sediment laden water to the environment can be catastrophic for fauna and ecosystem function, if not managed properly. Site specific erosion and sediment controls and management plans will be developed in accordance with best practice guidance and will be implemented across the Project footprint. The residual risk of sedimentation from earthworks was assessed for short term construction effects and was determined to have a magnitude of Low or Moderate after mitigation measures are implemented and depending on the size of works relative to the catchment size.

176. Water quality effects during construction can result when runoff comes into contact with substances such as concrete or from wood waste leachate runoff. The overall potential effect from of this runoff is similar to that of sedimentation. However the risk of residual adverse effects is more a feature of practice. Application of best practice in accordance with relevant guideline documents discussed below will result in the magnitude of effects being Low.

Long term effects – road operation

177. Culverts have the potential to restrict fish passage to upstream habitats if constructed poorly. 33 culverts are proposed for the Project main works, along the road alignment and access roads. The majority of these are in the headwaters at close to 300 m above sea level and have only intermittent habitat upstream of them. Further, many are located upstream of existing natural and artificial barriers. The limited amount and quality of upstream habitat means the magnitude of effect of culverts, in terms of fish passage, is No Effect to Low.

178. Stormwater runoff can impact water quality, flow regimes and erosion potential of streams. Stormwater controls will be implemented across the site which address both quality and quantity and are consistent with best practice methods. Further the treatment approach will be an improvement on the current scenario. The magnitude of effect will be Negligible to Low following the implementation of the proposed stormwater management approach.

179. The most substantial effects on freshwater ecology will occur from the loss and modification of streams, resulting in reduced habitat quality and availability (stream length and area). In total, 13,365 m stream length (8,305 m^2 stream bed area) will be affected by the Project. Culverts comprising approximately 2,300 m will be constructed, along with 8,014 m stream diversions (11,429 m^2 stream bed area). The overall effect of the stream modification is Very High and an offset package has been prepared to address these effects. The offset package includes creation of 9,500 m^2 new stream habitat and riparian enhancement and restoration planting along approximately 23 km of gully stream system.

180. Potential effects from the Project on freshwater ecology are discussed in more detail in the sections below with specific reference to the ecological values, magnitude of effect following mitigation and overall level of effect in accordance with EcIAG.

Table H.10: Summary of magnitude of effects across proposed activities.

Effect/activity	Step 2: Magnitude <u>with no</u> mitigation	Reason for impact without mitigation (spatial extent, duration, time scale)	Key mitigation measures	Step 2 repeated to determine magnitude <u>with</u> mitigation
Construction effects (short term)				
Impacts on freshwater fauna: injury and mortality	Moderate	If fish are not removed from the footprint before works commence, there could be a loss of life however this would only be in a small area relative to the remaining habitat available and likely to be predominantly in areas with low numbers of fish and koura. It is possible that certain parts of the site are hot spots for particular species so changes to the proportion of the population could be discernible. Injury or mortality could be a permanent effect.	Fish recovery protocols have been prepared that require fish salvage to take place prior to works commencing in stream at all stream works sites.	Negligible to Low
Sedimentation from earthworks	High	Earthworks will occur progressively in stages over an area of approximately 180 ha to construct the Project. The works will occur over a period of approximately four to five years. Uncontrolled discharges of sediment laden water are an inherent risk associated with earthworks, particularly at this scale. The works cross over multiple catchments therefore has the potential to impact tributaries and main streams. Streams across the footprint are sensitive to sediment as are macroinvertebrates and some fauna present. An uncontrolled discharge of sediment could fundamentally change the character and composition of the stream systems present.	A staged approach to earthworks to reduce open areas. Sediment and erosion controls to GD05 standard. Site Specific Erosion and Sediment Control Plans to be developed for each stage. Stream works procedure prepared, wherever practicable works to be completed in dry conditions.	Low to Moderate
Water quality during construction	High	Wood waste leachate can form when mulched vegetation is stockpiled and if this leachate enters streams, can affect oxygen levels in the stream. Water that comes into contact with concrete can become highly alkaline, which can alter the pH of receiving waters. Both of these scenarios can result in changes to water quality that can be fatal to aquatic fauna.	Vegetation clearance protocols, sensible placement of cleared vegetation, management of placement to reduce risk. Run off from these areas will be collected and treated to avoid and minimise potential effects. Implementation of erosion and sediment control measures.	Negligible to Low

Effect/activity	Step 2: Magnitude with no mitigation	Reason for impact without mitigation (spatial extent, duration, time scale)	Key mitigation measures	Step 2 repeated to determine magnitude with mitigation
Operational effects (long term)				
Loss of fish passage to headwater catchments	Moderate to High	Diadromous fish move between the ocean and freshwater systems and culverts can prevent passage if not designed correctly. Minimal habitat value in many catchments and some existing natural and artificial barriers, however there is a legal and policy framework that promotes the provision of fish passage. Further, given the proposed stream length loss reducing potential fragmentation of habitat is important. Existing barriers to fish passage at downstream extent of most sub catchments. Permanent effect and can impact life cycles of diadromous fish and reduce area of available habitat. Much of the habitat upstream of the alignment is intermittent and degraded, likely to provide only temporary habitat value. The magnitude of effect is driven by the extent of suitable habitat upstream of the potential barrier (and assessed individually for each catchment).	Bridges proposed in key catchments (Mangamanaia Stream, Manawatū River) to avoid potential barriers. Culverts designed for fish passage wherever practicable. Magnitude following mitigation culvert dependent and assessed on a catchment basis.	No effect to Low
Stormwater quality and quantity effects	Moderate	Stormwater runoff from roads can contain a wide range of contaminants including heavy metals, hydrocarbons, sediment. Contributing catchments modified through diversion of stormwater to treatment devices. Potential to either reduce or increase flows within stream channels and subsequently erosion in-stream. Without treatment, these contaminants can be toxic to aquatic life if present in sufficiently high concentrations. Some stormwater treatment devices can introduce thermal pollution, which can have subsequent effects on aquatic fauna and toxicity of some contaminants. Relative impact determined on a catchment basis.	Proposed stormwater approach incorporates treatment train approach. Thermal pollution minimised through use of wetlands and swales. Stormwater management approach designed to Transport Agency standards.	Negligible to Low
Modification or loss of stream habitat	Very High	Modification to stream ecological function and values through either culverting or infilling, and consequential diversions. Total of 13.365 km stream impacted across the alignment, comprising 2.3 km culverts. 8 km newly created diversions along the alignment.	Residual effects addressed through habitat provided by diversions and stream enhancement in the wider catchment. Embedded culverts, lengths minimised as much as possible. Offset	Very High, but can be offset to result in no net loss in ecological

Effect/activity	Step 2: Magnitude with no mitigation	Reason for impact without mitigation (spatial extent, duration, time scale)	Key mitigation measures	Step 2 repeated to determine magnitude with mitigation
		Reduces the potential for groundwater interaction, riparian zone interaction and introduces artificial substrates and modified flow regimes and habitat structures. Overall reduced extent of natural streambed habitat and ecological function. Relative impact determined on a catchment basis.	required. Creation of stream diversion channels. Offset required through replanting and creation of stream diversions	function effect

Construction effects

Impacts on freshwater fauna

181. In the absence of fish salvage, activities such as culvert placement and stream in-filling (spoil sites and road embankments) can cause stranding, injury or mortality to native freshwater fauna (fish and kōura). In addition, temporary restrictions to fish passage during construction may impact a population's reproductive success.

182. The magnitude of potential effect on native freshwater fauna is driven by the nature of the activity, the area of stream disturbance, density of fish present in each area, the ability of fish to escape disturbance and the controls applied. The conservation status of fish species is also relevant when assessing the potential overall level of effect.

183. Fish are anticipated to be present within all catchments and stream types across the Project. Intermittent streams are expected to only provide temporary habitat during winter peak flows. Fish populations are expected to be small in the headwaters of catchments 2, 3, 4, 5, 6 and 7 due to the elevation of these sites and existing barriers to fish passage (natural and artificial).

184. The direct effects of in-stream works on freshwater fauna can be avoided by undertaking works in summer months when intermittent streams are likely to be dry and fish absent. Effects can be further minimised and mitigated by implementing Fish Recovery Protocols ("**FRP**") as part of Stream Works Procedures ("**SWP**"). FRP have been drafted for inclusion in the EMP.

185. All suitable habitats will be fished prior to in-stream works commencing, using a combination of fish recovery methods (electric fishing, nets/traps, slow dewatering and sorting through dewatered materials) in different habitats as appropriate. Each of these methods has inherent risks and site-specific recovery protocols will be developed at the same time as the construction methods to minimise potential additional effects on fish during recovery and to provide for the most effective recovery approach.

186. Intermittent streams in the headwaters of the catchments 2, 3, 4, 5, 6 and 7 are expected to provide less habitat for native fish, and fauna are expected to migrate downstream to areas of continual flow (during summer months).

187. Fish numbers are expected to be highest in the Manawatū River and Mangamanaia Stream. Many of the other catchments have barriers to fish passage (catchments 2 to 7) or provide a low-quality habitat (catchments 1 and 8).

188. Works within catchment 2C, 4 and 5 are those most likely to impact fish as these catchments have existing fish records or are located in areas of higher quality or more prevalent habitat. For instance, Catchment 4 has the most permanent habitat to be affected and has an existing population of the non-diadromous upland bully.

189. Temporary restrictions to fish passage during construction works could potentially impact recruitment of particular species. The duration of the restriction, the time of year and the relative catchment location all contribute to the potential impact on fauna. For works being undertaken in intermittent streams, or those dry at time of construction, fish passage will not be required to be provided.

190. In larger permanent streams, including the Managamanaia Stream, Catchment 4 and Catchment 5, fish passage during works is likely to be required. Fish passage should be provided through all temporary diversions or works areas during peak migration times for target species, the details of which are included in the Freshwater Management Plan within the EMP. Reference is made to the Ministry of Primary Industries (MPI) fish migration calendar.[52] Notwithstanding the potential temporary impact on passage, the short duration of the potential impact means that the magnitude of effect is low.

191. It is proposed that appropriate FRP will be applied across the site, with intensity of effort in any given area dictated by the likelihood of 'at risk species' or type of habitat present. The FRP within the EMP includes procedures for:

(a) Identifying area of likely fish populations;

(b) Recovery of fauna (including fish and kōura) prior to in-stream works commencing;

(c) Measures to prevent fish returning to cleared areas;

(d) Rescue of fauna from spoil or dewatered materials;

(e) Relocation of fish; and

[52] Smith, J (2014). Freshwater Fish Spawning and Migration Periods. Prepared for Ministry of Primary Industries, by NIWA (Client Report HAM2014-101).

(f) Reporting.

192. The overall level of effects on a catchment scale and following mitigation measures is described in Table H.11. Following the successful implementation of a comprehensive FRP and temporary fish passage measures the overall effect on freshwater fauna will reduce to Low or Very Low.

Table H.11: Overall effect of the Project on freshwater fauna injury and mortality.

Catchment	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Step 4: Overall effect
Manawatū River	High	Nine species of native fish present in the catchment including three At Risk Declining species. IBI (78) indicative of excellent biotic integrity. Manawatū River is recognised as a trout fishery (non-ecological value).	Negligible	Temporary and partial effects resulting from construction works within the river. Works will be undertaken in dry conditions and fish will be salvaged from within the coffer dams during dewatering. Fish passage during construction unlikely to be restricted by the construction piers.	Very Low
Catchment 1	Low	Highly modified, agricultural catchment. Shortfin eels recorded but no other species despite low elevation. No threatened species expected to be present. Fish values are very low with an IBI of 24 indicative of a very poor biotic integrity.	Low	Fish salvage will be undertaken and there is available habitat for relocation. Upstream habitat of low quality, fish passage to be provided during temporary works.	Very Low
Catchment 2	High	Four native fish species including longfin eel. More diverse assemblage of fish and likely to be present at crossing point. IBI (70) indicative of excellent biotic integrity.	Low	Works within the main Mangamanaia Stream are restricted to BR07 where rip rap proposed in streambed. Potential impact on upstream passage during in-stream works to be mitigated by enabling passage.	Low
	Moderate	Tributaries 2E and 2C. Kōura and longfin eel (At Risk Declining) recorded within these catchments, however at this elevation, low diversity and minimal habitat mean very low numbers of fish are expected.	Low	Fish salvage will be undertaken and there is available habitat for relocation. Majority of headwater habitat will be lost and so temporary passage not required for much of catchment.	Very Low
Catchment 3	Moderate	Tributary 3A. Several mature longfin eel (At Risk Declining), shortfin eel and kōura. However at this elevation, low diversity and minimal habitat mean very low numbers of fish are expected. IBI of 52 indicative of moderate biotic integrity.	Low	Fish salvage will be undertaken and there is available habitat for relocation. Majority of headwater habitat of Catchment 3B will be lost and so temporary passage limited to upper Catchment 3A.	Low

Catchment	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Step 4: Overall effect
Catchment 4	High	Despite presence of artificial barrier to passage, moderate diversity. Non-diadromous upland bully, and At Risk Declining longfin eel. Shortfin eel, koura and unidentified bully recorded. Large numbers and reasonable amount of habitat available. Upland bully likely to spawn near home range and during peak spawning season which coincides with earthworks season.	Low	Fish salvage will be undertaken and there is available habitat for relocation. Fish passage required to be provided during temporary works particularly in main-stem. Less important in areas of proposed spoil.	Low
Catchment 5	Moderate	Kōura and longfin eel (At Risk Declining) recorded within these catchments, however at this elevation, low diversity and minimal habitat mean very low numbers of fish are expected, indicative of very poor biotic integrity.	Low	Fish salvage will be undertaken and there is available habitat for relocation. Fish passage required to be provided during temporary work particularly in catchment 5B. Less important in 5A as proposed spoil site so habitat will be lost.	Very Low
Catchment 6	Moderate	Only kōura caught (IBI = 0). Assume same as Catchment 5 and longfin may be present.	Low	Fish salvage will be undertaken and there is available habitat for relocation. Fish passage not required for temporary works as no upstream habitat.	Very Low
Catchment 7	Moderate	IBI of 54 indicative of moderate biotic integrity. Kōura, shortfin and longfin eel (At Risk Declining) recorded within Catchment 7. Barrier at downstream end of catchment (Kiwirail culvert).	Low	Fish salvage will be undertaken and there is available habitat for relocation. Fish passage not required for temporary works in upstream 7A and 7B works as no upstream habitat will remain.	Very Low
Catchment 8	Low	Highly modified, agricultural catchment. Shortfin eels and common bully recorded but no other species despite low elevation. No threatened species expected to be present. IBI indicative of poor biotic integrity (IBI = 24).	Low	Fish salvage will be undertaken and there is available habitat for relocation. Upstream habitat of low quality, fish passage to be provided during temporary works.	Very Low

Catchment	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Step 4: Overall effect
Catchment 9	High	IBI of 52, indicative of moderate biotic integrity. Expect a variety of species present within catchment due to connectivity.	Negligible	Very minimal habitat to be impacted during main works. Habitat disconnected from Pohangina by elevation and fragmentation. Fish passage not required for temporary works as no upstream habitat.	Very Low

Potential sedimentation from earthworks, construction and in-stream works

193. In the absence of controls, there is potential for an uncontrolled discharge of sediment laden water into the receiving environment during construction works for the spoil sites, road construction, culvert construction and creation of diversions.

194. The effect of excess in-stream sedimentation is recognised as a major impact of changing land use on river and stream health, through changes in water clarity and sediment deposition.

195. Sediment entering stream systems can impact water clarity through sediment suspended within the water column ('suspended sediments'). Many native species are tolerant of elevated suspended sediment, measured either by turbid water or high concentrations of total suspended solids ("**TSS**").[53] The banded kōkopu (*Galaxias fasciatus*) is a notable exception, known to exhibit avoidance behaviours at 25 NTU[54] however this species has not been recorded within the Project area and there are actually very few records within the wider Manawatū catchment.[55]

196. Sedimentation has more noticeable effects on physical habitats of streams when it is deposited on the streambed ('deposited sediments'). Excess deposited sediment can clog the small spaces (interstitial) between hard stream substrates which impacts aquatic macroinvertebrates, alters food sources (i.e. macroinvertebrates for predation by fish) and removes egg laying sites for fauna.

197. Many of the streams within the Project area currently experience elevated sediment loads, evidenced by turbid water and dominance of silt and sand substrates in what are naturally hard bottom streams. Turbid water was observed over several catchments during baseline water quality monitoring[56] and was particularly bad downstream of an online pond in Catchment 4. TSS was also elevated across most catchments.

198. Deposited fine sediment was typically recorded well above Schedule E targets of <20%. Median and mean deposited sediments for each catchment are

---

[53] For summary of research see Clapcott, J.E., Young, R.G., Harding, J.S., Matthaei, C.D., Quinn, J.M. and Death, R.G. (2011) Sediment Assessment Methods: Protocols and guidelines for assessing the effects of deposited fine sediment on in-stream values. Cawthron Institute, Nelson, New Zealand.
[54] NTU is a Nephelometric Turbidity Unit. NTU is the unit used to measure the turbidity of a fluid or the presence of suspended particles in water.
[55] McQueen, S. 2017. The case of the missing kōkopu. http://blog.forestandbird.org.nz/the-case-of-the-missing-kokopu/
[56] James (n 14)

shown on Figure H.4. Only Catchments 5, 6 and 7 met or were close to meeting deposited sediment targets which are intended to protect ecosystem health.[57] This indicates that the existing agricultural land use is contributing to existing sediment loads, and those streams within fenced, riparian margins typically have lower sediment deposition and will be more sensitive to change.

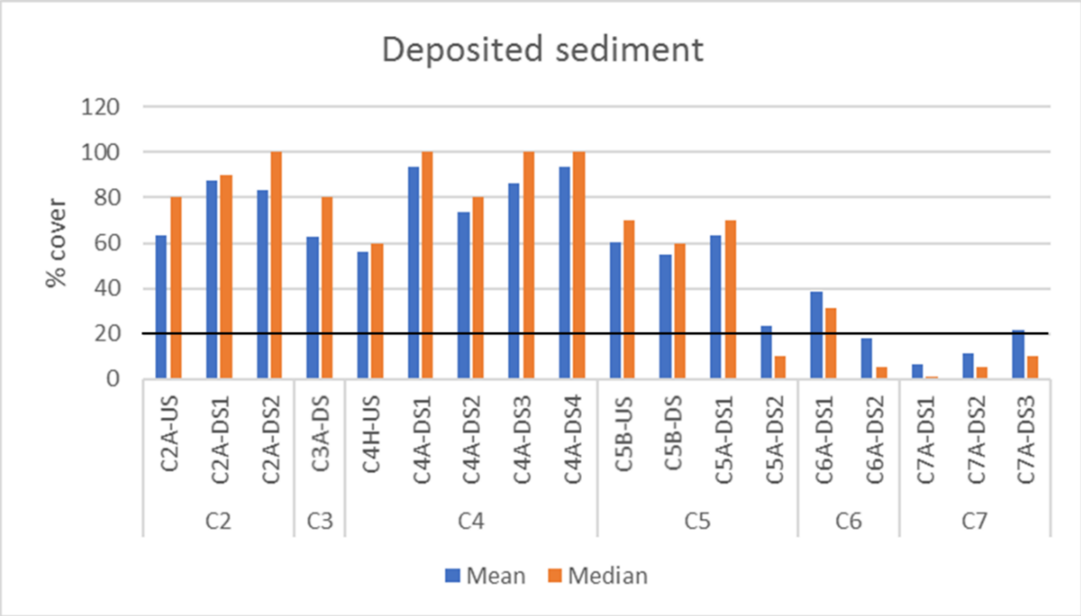


Figure H.4: Mean and median deposited sediment across the Project alignment. Black line shows the One Plan Target of <20%. No sampling undertaken in C1, C8 and C9. (Source: EOS, November 2019[58]).

199. The potential magnitude of sedimentation effects without mitigation can be Very High. The implementation of a Erosion and Sediment Control Management Plan ("**ESCP**"), with Site Specific Erosion and Sediment Control Plans ("**SSESCP**") will reduce the potential magnitude of effect of construction sedimentation effects.

200. Erosion and sediment controls will be adopted for all works areas and designed, constructed and maintained in accordance with GD05.[59] All areas will be managed to the same high standard of industry best-practice, with recognition of the sensitivity of the receiving environment, the available space for controls, the duration of works and the local topography.

---

[57] A deposited sediment guideline of <20% is recommended within Clapcott et al, (2011) as well as within schedule E of the One Plan (Table H.9).
[58] James (n 14).
[59] Auckland Council Guideline Document 2016/005 *Erosion and Sediment Control Guide for Land Disturbing Activities in the Auckland Region, June 2016*

201. The principles associated with the Project's erosion and sediment control design are included within the ESCP and include, in brief:

(a) Minimising sediment generation and discharge from the Project;

(b) Implementation of a treatment train approach to maximise treatment efficiency;

(c) Implementation of clean water diversions;

(d) Staging of works, to limited soil disturbances;

(e) Chemical treatment for sediment retention ponds and decanting earth bunds; and

(f) All works to be implemented by the dedicated Erosion and Sediment Management Team.

202. While the entire construction period is four to five years, works within individual catchments may occur over a much shorter timeframe. Further the bulk earthworks season comprises only seven months of the year unless particular conditions are able to be met for winter works. The earthworks areas will be stabilised and 'shut down' outside of the active earthworks season. This further reduces the potential time for sediment generation.

203. Specific measures are proposed for works within watercourses or wetlands (described in SWP). Wherever possible, works within watercourses and wetlands will be undertaken in the dry or offline, with flows diverted around the works area. Temporary or permanent diversions will be stabilised prior to being made 'live'.

204. The proposed approach to erosion and sediment control is described in more detail in the ESCP and within **Mr Stewart's** Technical Assessment A (Erosion and Sediment Control). **Mr Stewart** has undertaken Universal Soil Loss Equation ("**USLE**") modelling to inform an assessment of effects and to guide management interventions. **Mr Stewart** notes that that sediment yields modelled for the project are realistic and probably conservative as the USLE model generally overestimates potential sediment yields.

205. The proportion of active earthworks area within each catchment will vary across the construction period and the numbers produced for the USLE modelling assume the entire site is open and during the first year when there is the highest potential for sediment generation. This adds a further element of conservatism to the effects assessments.

206. An assessment of the potential sediment loads from the Project in relation to water quality effects has been undertaken and is reported in **Mr Hamill's** Technical Assessment C (Water Quality). I refer to his findings in my assessment of effects on freshwater ecology.

207. The USLE modelling suggests that discharges from earthworks sites during rain events may result in sediment loads and suspended sediment concentrations two to three times higher than baseline conditions. This increase is attributed to the active earthworks area only and does not consider the proportion change at a whole of catchment scale (i.e. in the context of the wider contributing catchment).

208. Further analysis using estimated sediment yields for existing catchment land use has been extrapolated to include the area of each catchment that lies beyond the works footprint, thereby providing a catchment context (Table A.4, Technical Assessment A (Erosion and Sediment Control)). This provides a more meaningful representation of the increase in sediment load to the stream at the downstream extent of the Project works.

209. When considered at a catchment scale, which I consider to more accurately represent the magnitude of effects, the percentage change from existing conditions is much less than two to three times (as indicated in [207] above). The estimated potential change in sediment loads within Catchments 1, 9, 2 and 8 represent increases of between 4% (Catchment 1) and 11% (Catchment 8). The largest potential increase in sediment load occurs within Catchment 7 and 5 at approximately a 50% increase. The potential magnitude of effects associated with each catchment is further described in Table H.12 below.

210. It is expected that there will be an increase in sediment loss from the land and consequently entering the environment during construction. The effects of this are expected to be short term, in that they will only occur for the duration of construction in a given catchment. Further, many of the more sensitive streams are very steep and are expected to flush sediment through rapidly. Studies on sediment movement within headwater streams indicates that the majority of sediment moves downstream to lowland areas. Where sediment does accumulate, it is mobilised downstream during subsequent rainfall events with sediment loads remaining relatively constant.

211. The baseline condition indicates that sediment deposition is an existing issue related to extensive agricultural land use in many of the catchments. The lower reaches of Catchment 5, 6 and the upper reaches of sub-catchment 7A are

exceptions to this, likely due to the presence of relatively intact riparian margins and steep nature of the streams.

212. I consider that <u>during construction</u> the potential increase in sediment could result in the baseline conditions being either 'discernibly changed' or 'partially changed' consistent with a potentially Low or Moderate magnitude of effects respectively(Table H.20). The modelled potential increase in sediment loads and consideration of the baseline (existing) condition within each catchment is incorporated into this magnitude on a catchment basis. This magnitude applies only to potential effects during the construction period.

213. The proposed construction activities will last four to five years across the entire project and a much shorter time period on a catchment scale. This duration is consistent with the EcIAG 'Temporary - Short Term' scale which is relevant to determining magnitude. Following completion of the project, the magnitude of effect relating to sediment will reduce to Low. That is, while there may be a discernible change, the underlying character of the environment will be similar to predevelopment. The first bedload moving flow event following completion of construction may result in the magnitude of effect being Negligible.

214. Following the implementation of mitigation measures the overall effect during construction when accounting for ecological values will be Low to Moderate across the majority of catchments (refer Table H.12). The overall level of effect in Catchment 5 and 7 is anticipated to be High following implementation of mitigation measures and during construction.

215. I consider that this overall level of effect is acceptable given the nature of the work and the duration of the Project, and that specific offset or compensation measures are not necessary to address this effect. The works may impact streams for seven months of the year and will be completed within five years (and less in some catchments). Further, the sediment load is likely to be less than modelled based on the reported conservatism in **Mr Stewart's** sediment yield estimates. To provide certainty that any potential change is 'barely discernible' following construction Aquatic Ecology Monitoring Protocols ("**AEMP"**) are proposed as part of the Freshwater Ecology Management Plan ("**FEMP**").

216. Pre-construction monitoring of water quality, ecology and deposited sediment will provide baseline data upon which to determine the variable characteristics of those parameters across a range of stream states and seasons. During construction routine monitoring of those parameters will be undertaken, and

event-based monitoring will occur in respect to specified issues should they occur on site.

217. Monitoring will continue following completion of the project to confirm that the post-construction state of the streams returns to a pre-development state. Conditions of consent have been developed in regard to this.

Table H.12: Overall effect of short-term sedimentation effects during construction (after mitigation).

Catchment	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Step 4: Overall effect during construction
Manawatū River	High	High IBI and recognised as having ecological values. Part of a wider catchment with levels of degradation resulting from agricultural land use. Elevated levels of suspended sediments present in systems during flood currently.	Low	Erosion and sediment controls implemented in accordance with GD05. Scale of works in context of the catchment and existing water quality. Modelled increases in sediment load unlikely to result in more than discernible change in baseline condition during construction.	Low
Catchment 1	Low	Highly modified watercourses with poor diversity and paucity of fauna. Low lying catchment, with agricultural land use to the stream margins and presence of macrophytes indicating elevated levels of nutrients. Evidence of regular channel clearance for maintenance. Sediment deposition observed during site assessments.	Low	Erosion and sediment controls implemented in accordance with GD05. Modelled increases in sediment load unlikely to result in more than discernible change in baseline condition during construction.	Low
Catchment 2	Moderate	Specifically sub-catchments 2C, 2E and lower reaches of Mangamanaia Stream. Mixed existing values, with steeper sections in the headwaters higher value. Focus is on the low lying, depositional areas which have a lower current value than other parts of the catchment. Lower 2C stream reaches have macrophytes, nutrient enrichment and deposition. Mangamanaia Stream is cobble bottom but currently impacted by sediment deposition above Schedule E targets.	Low	Erosion and sediment controls implemented in accordance with GD05. Modelled increases in sediment load unlikely to result in more than discernible change in baseline condition during construction.	Low

Catchment	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Step 4: Overall effect during construction
Catchment 3	Moderate	Sub-catchments 3A and 3B both contain steep catchments with some vegetated margins, particularly in the headwaters. The upper reaches have a lower gradient and a moderate value wetland is present at the upper extent of 3B. Fish species are indicative of moderate biotic integrity and macroinvertebrates indicate poor and fair water and habitat quality. Sediment deposition above Schedule E targets.	Moderate	Erosion and sediment controls implemented in accordance with GD05. Modelled increases in sediment load *ca* 27% at catchment scale, but higher in sub-catchments. Potential to result in partial change to baseline condition during construction.	Low
Catchment 4	Moderate	Most of the upper reaches have been modified through agricultural land use, with stock access generally unrestricted and damming of streams to create farm ponds. Elevated suspended sediments present downstream of existing farm pond. Non-diadromous fish (upland bully) present in catchment as well as other fish species. Macroinvertebrate indices all indicative of poor water and habitat quality. Main channel a depositional zone as indicated by sediment deposition above Schedule E targets. Areas with stock access have pugging further influencing sediment loads into stream reaches. Lower reaches of catchment 4 fall steeply through the MSGR to the Manawatū River in the Gorge. Upper MSGR reaches impacted by sediment deposition (above Schedule E), likely driven by discharges from the existing pond.	Moderate	Erosion and sediment controls implemented in accordance with GD05. Catchment 4 will be impacted in numerous locations along its length. Much of the length is across the ridgetop and at a lesser gradient that the tributaries flowing north to south. Therefore, expect more higher occurrence of deposition. Modelled increases in sediment load have the potential to result in a partial change in baseline condition during construction.	Moderate
Catchment 5	High	The main stem of Catchment 5 is located within the MGSR, with 5A to the upper east and 5B to the upper west. The upper reaches of these sub-catchments are characterised by steep, hard bottom stream systems in agricultural land use with fragmented riparian margins.	Moderate	Erosion and sediment controls implemented in accordance with GD05. Steep catchment, with minimal depositional zones however	High

Catchment	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Step 4: Overall effect during construction
		Macroinvertebrate indices highest of affected catchments, indicative of good and excellent water and habitat quality. Some existing sediment deposition above Schedule E targets in headwaters, however cobbles and gravels provide habitat heterogeneity. Steep upper catchments, and falling steeply through the MSGR to Manawatū River in the gorge. Sediment deposition within MSGR meets Schedule E targets.		significant portion of catchment subject to works. Modelled increases in sediment load have the potential to result in a partial change in baseline condition during construction.	
Catchment 6	High	Catchment 6 predominantly in QEII covenant. Margins protected and planted. Uppermost portion of stream within agricultural land use. Catchment falls steeply toward Manawatū River. Sediment deposition close to or meeting the Schedule E targets, with lower deposition within the MSGR.	Moderate	Erosion and sediment controls implemented in accordance with GD05.Only very small portion of catchment being affected by works however modelled increases in sediment load have the potential to result in a partial change in baseline condition during construction.	Low
Catchment 7	High	Consists of three sub-catchments. Majority of works within main channel of 7B and headwaters of 7A. 7A higher value, with intact riparian margins, fencing and good in-stream macroinvertebrate values. Some sections of stream exhibit depositional areas, however predominantly a steep catchment. 7B of lower current value in agricultural land, minimal margins and stock access unrestricted. High value raupō wetland at confluence of three tributaries.	Moderate	Erosion and sediment controls implemented in accordance with GD05. Extensive works proposed within the catchment. Modelled increases in sediment load unlikely to result in more than discernible change in baseline condition during construction.	High

Catchment	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Step 4: Overall effect during construction
		Sediment deposition measured within sub-catchment 7A, all sites meeting Schedule E targets, with lower reaches near Manawatū River slightly higher.			
Catchment 8	Low	Highly modified watercourses with poor diversity and paucity of fauna. Low lying catchment, with agricultural land use to the stream margins and presence of macrophytes indicating elevated levels of nutrients. Evidence of regular channel clearance for maintenance. Sediment deposition observed during site assessments.	Low	Erosion and sediment controls implemented in accordance with GD05. Modelled increases in sediment load unlikely to result in more than discernible change in baseline condition during construction.	Low
Catchment 9	High	The topography of the catchment is steep and the majority of the stream reaches are well vegetated. IBI of 52, indicative of moderate biotic integrity. Expect a variety of species present within catchment due to connectivity. Expect sediment deposition to be similar to Catchments 6 and 7.	Low	Erosion and sediment controls implemented in accordance with GD05. Only very small portion of catchment being affected by works and some distance from stream channels Modelled increases in sediment load unlikely to result in more than discernible change in baseline condition during construction.	Low

Potential water quality effects from construction activities

218. Water quality of streams and aquatic systems can be affected by other activities being undertaken during construction.

219. Vegetation clearance can have potential impacts on stream systems in two main ways. Removal of vegetation can expose soil making it more prone to erosion, resulting in increased sedimentation in streams. These effects can be addressed through implementation of erosion and sediment controls as described in the previous section.

220. Secondly, when cleared vegetation is stored as chip or mulch a 'wood waste leachate' can form which has a high biochemical oxygen demand ("**BOD**") and dissolved organic matter. If this leachate, or large quantities of mulch, enter streams, the dissolved oxygen content can be reduced. This can cause avoidance behaviours or fatality in aquatic fauna.

221. **Mr Hamill** has addressed the potential effects of these activities on water quality in Technical Assessment C (Water Quality). I refer to his assessment when considering magnitude of effect.

222. Mitigating these effects can be achieved through good practice during construction. Management procedures have been developed within the Construction Environmental Management Plan ("**CEMP**") and the EMP.

223. Vegetation Clearance Protocols ("**VCP**") are proposed as part of the EMP which includes procedures for:

    (a) minimising the area and duration of soil exposure from vegetation clearance,

    (b) minimising the volume of vegetation to be mulched,

    (c) locating wood residue piles with an appropriate separation distance from streams, and

    (d) minimising potential wood waste leachate from these piles.

224. Water that encounters hazardous substances during construction can adversely impact aquatic fauna as these can be toxic. One such substance is concrete which is highly alkaline and can alter the pH of receiving waters. Potential effects resulting from concrete or other substances can be managed through sensible construction processes. A Hazardous Substances

Procedure has been developed as part of the ESCP which describes the processes to be implemented to minimise potential risks to aquatic life.

225. The risk of concrete affecting stream water quality is low because the areas affected are limited in scale and works are to occur in dry conditions (i.e. not directly in water). Pre-cast concrete structures are being used across the project, which will minimise some of the risk associated with concrete pouring.

226. With the implementation of the described controls, I consider that the magnitude of effects resulting from vegetation clearance or water coming into contact with hazardous substances is Low (refer to Table H.13).

Table H.13: Potential effects of hazardous substances on freshwater ecology (after mitigation).

Catchment	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Step 4: Overall effect
Manawatū River	High	Nine species of native fish present in the catchment including three At Risk Declining species. IBI (78) indicative of excellent biotic integrity. Manawatū River is recognised as a trout fishery (non-ecological value). Part of a wider catchment with levels of degradation resulting from agricultural land use. Elevated levels of suspended sediments present in systems during flood currently.	Low	Scale of project relative to river. Implementation of controls	Very Low
Catchment 1	Low	Highly modified watercourses with poor diversity and abundance of fauna. Limited upstream catchment and nutrient enrichment evident. Existing road crossings and modification of flow regime. Riparian margin absent. Macroinvertebrate indices indicative of poor water and habitat quality (MCI_sb = 63, QMCI_sb = 3.24, %EPT abundance = 0.00) and very poor fish biotic integrity (IBI = 24). Existing stream channels modified and straightened, appear to be subject to regular maintenance.	Negligible	Implementation of controls.	Very Low
Catchment 2	High	Watercourses affected by agricultural land use, stock access to streams. Headwaters of 2C higher value with relatively intact riparian margins and hard bottom substrates. Remainder of affected streams lower current value. Macroinvertebrate indices indicative of localised habitat and water quality issues. Highest in hard bottom upper catchment with restricted stock access (MCI = 104; 80, QMCI = 5.54; 4.12, % EPT abundance 32.88; 2.31). Lower reaches and headwaters of 2E indicative of poor water and habitat quality (MCI_sb = 60; 67; 70; 78, QMCI_sb = 2.69; 2.66; 2.61; 2.34, %EPT abundance = 1.96; 7.11; 0.46; 0.00) Lowland reaches of Mangamanaia Stream have excellent fish biotic integrity (IBI = 70), however steeper reaches expect to have lower	Low	Implementation of controls.	Low

Catchment	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Step 4: Overall effect
		diversity of fish due to reduced habitat availability and access restrictions (IBI estimated to be 24, 'very poor').			
Catchment 3	Moderate	Steep short catchment, with two main sub-catchments. Moderate value wetland upstream of potential stormwater impacts on sub-catchment 3A. Post development, limited upstream catchment. Riparian margin absent along lower reaches, present in parts in upper catchments. Macroinvertebrate indices indicative of poor water and habitat quality (MCI_sb = 67, QMCI_sb = 2.15, %EPT abundance = 0.99; MCI=89, QMCI = 4.03, %EPT abundance = 7.83) and moderate fish biotic integrity (IBI = 52). Existing stream channels modified and straightened, appear to be subject to regular maintenance.	Low	Implementation of controls.	Low
Catchment 4	Moderate	Watercourses affected by agricultural land use, stock access to streams. Gully systems with wetland habitats present. Remainder of affected streams lower current value. Macroinvertebrate indices indicative of localised habitat and water quality issues. Highest in hard bottom upper catchment with restricted stock access (MCI and MCI-sb= 64 to 88, QMCI = 2.19 to 4.32, % EPT abundance 0 to 8.64). Fish IBI 34, indicative of very poor, but healthy population of upland bully present in catchment.	Low	Implementation of controls.	Low
Catchment 5	High	Steep, hard bottom stream systems in agricultural land use with fragmented riparian margins. Some existing sediment deposition, however cobbles and gravels provide habitat heterogeneity. Macroinvertebrate indices highest of affected catchments, indicative of good and excellent water and habitat quality (up to MCI = 120). Moderate fish biotic integrity (48).	Low	Implementation of controls.	Low

Catchment	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Step 4: Overall effect
Catchment 6	High	Only kōura caught (IBI = 0). Assume same as Catchment 5 and longfin may be present. QEII protection over much of catchment. Riparian margins relatively intact, cobble bottom stream.	Low	Implementation of controls.	Low
Catchment 7	High	Consists of three sub-catchments, two potentially affected by stormwater. Fish index of biotic integrity indicative of moderate value (54). 7A higher value, with intact riparian margins, fencing and good in-stream macroinvertebrate values. Some sections of stream exhibit depositional areas, however predominantly a steep catchment. Macroinvertebrate indices reflect good to excellent water quality and habitat values, including in pasture headwaters. Sensitive EPT taxa present in headwaters (up to 44% EPT abundance). 7B of lower current value in agricultural land, minimal margins and stock access unrestricted. Macroinvertebrate indices and reflective of poor water quality and degraded habitat.	Low	Implementation of controls.	Low
Catchment 8	Low	Highly modified, agricultural catchment. IBI indicative of poor biotic integrity (IBI = 24). Evidence of regular channel clearance for maintenance. Macroinvertebrates confirm degraded state (MCIsb = 66).	Low	Implementation of controls.	Very Low
Catchment 9	High	Anticipate high value based on shading and riparian vegetation within gully systems. IBI of 52, indicative of moderate biotic integrity. Expect a variety of species present within catchment due to connectivity.	Low	Implementation of controls.	Low

Operational / long-term effects (other than modification / loss of stream habitat)

Fish passage

227. Many of New Zealand's native fish are diadromous, meaning they migrate to and from the sea as part of their lifecycle. Artificial structures and poor culvert design can restrict fish migration. Often this occurs as a result of culverts being perched, too steep or long, subsequent increases in water flow or a resultant laminar flow with insufficient roughness to allow effective fish movement.[60] The resultant decrease in fish mobility can result in fragmented populations, a reduction in population size, and limiting overall available habitat for freshwater fauna.

228. As discussed above, the existing fish populations are not particularly diverse or large and comprise diadromous and non-diadromous fish. Catchment 4 has a healthy population of upland bully, a non-migratory species. Many of the stream catchments affected by the Project are short and steep, with relatively small catchments. The available habitat is limited due to it being intermittent and steep, and there are existing natural and artificial barriers to fish passage along the Gorge.

229. Catchments 1, 2, 8 and 9 are more likely to have unrestricted fish passage due to low elevation. The upper reaches of Catchment 2 through to 7 are up steep gradients and upstream of barriers to passage. A complete survey of existing fish passage barriers has not been undertaken however natural and artificial barriers have been observed within several of these catchments.

230. 33 new culverts are proposed to be constructed along the alignment. A summary of the key features in respect of fish passage is provided in Table H.14. Refer to Drawing TAT-3-DG-H-1441 Cross Culverts Schedule for full design details. The longest culvert is 179 m long in sub-catchment 5B, while CU-08 is shorter, but comprises three barrels.

[60] Franklin, P., Gee, E., Baker, C. and Bowie, S. (2018). New Zealand Fish Passage Guidelines for Structures up to 4 metres. NIWA CLIENT REPORT No: 2018019HN.

Table H.14: Summary culvert details in relation to fish passage requirements. Taken from Cross Culvert Schedule (Dwg TAT-3-DG-H-1441-C). Where no passage is proposed, the length or type of upstream habitat has been provided for context.

Culvert ID	SIZE (mm)	NO. OF BARRELS	LENGTH (m)	GRADIENT (%)	FISH SPECIES	FISH PASSAGE TREATMENT	OUTLET STRUCTURE	STRUCTURE LENGTH (m)	STREAM CATCHMENT	UPSTREAM LENGTH (m)
CU-01	900 Ø	1	74	7.0%	NOT REQUIRED	EMBEDMENT	RIPRAP APRON	5	8A	0
CU-02	900 Ø	1	59	13.7%	NOT REQUIRED	EMBEDMENT)	RIPRAP APRON	5	8A	0
CU-03	1200 Ø	1	69	6.8%	CLIMBERS	EMBEDMENT	RIPRAP APRON	7	7B	-
CU-04	1200 Ø	1	86	0.9%	CLIMBERS	EMBEDMENT	RIPRAP APRON	5	5B	-
CU-05	1600 Ø	1	90	9.0%	NOT REQUIRED	N/A	RIPRAP APRON	7	5B	Habitat limited to stream diversion SD-MC05-01 on spoil
CU-06	750 Ø	1	88	6.8%	NOT REQUIRED	N/A	RIPRAP APRON	3	5B	0
CU-07	1600 Ø	1	179	7.2%	CLIMBERS	EMBEDMENT	RIPRAP APRON	7.2	5A	-
CU-08	2000W X 2000H BOX	3	71	1.9%	SWIMMERS	EMBEDMENT	RIPRAP APRON	16	4A	-
CU-08A	900 Ø	1	101	5.7%	CLIMBERS	EMBEDMENT	RIPRAP APRON	4	4A	-
CU-09	1200 Ø	1	106	3.0%	CLIMBERS	EMBEDMENT	RIPRAP APRON	5	4C	-
CU-10	1350 Ø	1	98	0.9%	NOT REQUIRED	N/A	RIPRAP APRON	5.4	4D	Habitat limited to stream diversion SD-MC10-04 on spoil
CU-11	900 Ø	1	59	5.5%	NOT REQUIRED	N/A	RIPRAP APRON	3.6	4A	0
CU-12	1050 Ø	1	86	3.0%	CLIMBERS	EMBEDMENT	RIPRAP APRON	4	4E	-
CU-13	750 Ø	1	76	6.3%	CLIMBERS	EMBEDMENT	RIPRAP APRON	3.0	4F	-
CU-14	900 Ø	1	112	11.6%	NOT REQUIRED	N/A	RIPRAP APRON	4	3A	20
CU-15	1200 Ø	1	127	2.9%	CLIMBERS	EMBEDMENT	RIPRAP APRON	5	3A	-
CU-16	750 Ø	1	88	7.0%	NOT REQUIRED	N/A	RIPRAP APRON	3.0	3B	0
CU-17	1200 Ø	1	130	15.2%	CLIMBERS	EMBEDMENT	RIPRAP BASIN	5	2C	-
CU-17A	900 Ø	1	56	0.9%	SWIMMERS	EMBEDMENT	RIPRAP APRON	7.2	2B	-
CU-17B	900 Ø	1	44	1.0%	SWIMMERS	EMBEDMENT	RIPRAP APRON	4	1B	-
CU-18	2000W X 1500H BOX	2	52	0.5%	SWIMMERS	EMBEDMENT	RIPRAP APRON	9.0	1B	-
CU-18A	2000W X 1500H BOX	2	35	0.5%	SWIMMERS	EMBEDMENT	RIPRAP APRON	9.0	1B	-
CU-18B	1050 Ø	1	25	0.4%	SWIMMERS	EMBEDMENT	RIPRAP APRON	4.2	1A	-

Culvert ID	SIZE (mm)	NO. OF BARRELS	LENGTH (m)	GRADIENT (%)	FISH SPECIES	FISH PASSAGE TREATMENT	OUTLET STRUCTURE	STRUCTURE LENGTH (m)	STREAM CATCHMENT	UPSTREAM LENGTH (m)
CU-19	1050 Ø	1	31	0.6%	SWIMMERS	EMBEDMENT	RIPRAP APRON	4.2	1A	-
CU-20	1350 Ø	1	30	0.8%	SWIMMERS	EMBEDMENT	RIPRAP APRON	5.4	1A	-
ACU-01	750 Ø	1	12	7.3%	CLIMBERS	EMBEDMENT	RIPRAP APRON	3.8	8A	-
ACU-03	1200 Ø	1	89	5.1%	CLIMBERS	EMBEDMENT	RIPRAP BASIN	9.2	5B	-
ACU-04	750 Ø	1	80	5.6%	NOT REQUIRED	N/A	RIPRAP APRON	3.0	5B	Connects to stream diversion SD-AC04-01 and then CU-06.
ACU-05	2000W X 2000H BOX	2	26	0.4%	CLIMBERS	EMBEDMENT	RIPRAP APRON	16.0	4A	-
ACU-05A	1050 Ø	1	28	3.1%	CLIMBERS	EMBEDMENT	RIPRAP APRON	5.3	4B	-
ACU-06	1050 Ø	1	32	1.1%	CLIMBERS	EMBEDMENT	RIPRAP APRON	5.3	4b	-
ACU-07	1350 Ø	1	27	5.5%	CLIMBERS	EMBEDMENT	RIPRAP APRON	5.4	3A	-
ACU-08	600 Ø	1	13	13.2%	NOT REQUIRED	N/A	USBR VI IMPACT BASIN	2.0	3A	0

231. As much as practicable, the NZ Fish Passage Guidelines have been considered in the design of the Project culverts.[60] Due to the steep nature of the stream systems, constructing culverts that minimise length while also providing a reasonable gradient is difficult. An assessment was made for each culvert as to the likely upstream habitat remaining following construction and location in the catchment to determine what species should be targeted in the culvert design.

232. Those culverts in the upper headwaters of the steep catchments were designed to be consistent with the natural gradients present and targeted towards climbing species. All culverts will be embedded to 25% to avoid perching and in an effort to maintain mean cross-sectional depth in adjacent stream reaches. All pipes are oversized and the aprons have low-flow channels built in. Given many of the catchments are intermittent, it is expected that streams will dry up and during this time, fish passage will not occur. This is consistent with pre-construction conditions.

233. Where upstream habitat was minimal, was only intermittent in nature or was going to comprise only constructed habitat following construction, fish passage measures were not incorporated into the design.

234. An assessment of the effects of fish passage at a catchment level is provided in Table H.15.

235. The provision of fish passage where practicable will result in the overall level of effects ranging from No Effect to Low in different catchments.

Table H.15: Overall effect of permanent culverts on fish passage (after mitigation).

Catchment	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Step 4: Overall effect
Manawatū River	High	Nine species of native fish present in the catchment including At Risk Declining longfin eel. IBI (78) indicative of excellent biotic integrity. Manawatū River is recognised as a trout fishery (non-ecological value).	Negligible	A single large pier will be located in the centre of the river, however fish passage around the pier will be unimpeded. Therefore fish passage will not by restricted within the Manawatū River.	Very low
Catchment 1	Low	Fish values are very low with an IBI of 24 indicative of a very poor biotic integrity. A single species, shortfin eel, was recorded within the Catchment. Other species may be able to access the streams, however the available habitat is poor due to channel modification, extensive aquatic vegetation growth and agricultural land use.	Low	A total of six culverts will be constructed in Catchment 1. All culverts will be embedded and at a grade that enables passage to swimming species (all less than 1%). There is limited existing upstream habitat and following construction habitat will comprise primarily constructed stream channels or modified straightened streams.	Very Low
Catchment 2	High	Four native fish species including longfin eel. More diverse assemblage of fish and likely to be present at crossing point. IBI (70) indicative of excellent biotic integrity. Kōura and longfin eel (At Risk Declining) recorded within these sub-catchment 2C, however at this elevation low diversity and minimal habitat very low numbers of fish are expected.	Low	Bridge within the main stem Mangamanaia Stream, means permanent fish passage effects are avoided. Two culverts are proposed to be constructed. CU-17 is in the headwaters connecting two stream diversions and CU-17A is on the low-lying land to the east of the Managamanaia Stream. CU-17 has a steep gradient (15.2%) but targeting climbers and post-construction habitat will be restricted to constructed stream diversion channels.	Low
Catchment 3	Moderate	Tributary 3A. Several mature longfin eel (At Risk Declining), shortfin eel and kōura. However at this elevation, low diversity and minimal habitat mean very low numbers of	Low	Five culverts in sub-catchments 3A and 3B. CU-16 services only a cut-off drain and no fish passage is provided. Four other culverts all in 3A. Only two of these connect to upstream habitat and	Low

Catchment	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Step 4: Overall effect
		fish are expected. IBI of 52 indicative of moderate biotic integrity.		both will be embedded. CU-15 provides connectivity to moderate value wetland habitat and will be constructed at 2.9% grade. ACU-07 (grade 5.5%) provides connectivity to modified habitat and an online pond. Given the location of these culverts in the catchment, climbing species are targeted.	
Catchment 4	High	Despite presence of artificial barrier to passage, moderate diversity. Non-diadromous upland bully, and At Risk Declining longfin eel. Shortfin eel, koura and unidentified bully recorded. Large numbers and reasonable amount of habitat available. Expect only climbers (and non-migratory species) in this part of catchment.	Low	Ten culverts proposed within catchment 4 and will be embedded. Culverts on the main channel are designed for swimming species, while all others target climbing species, given the location in the catchment. Of most importance, are ACU-05 and CU-08 is at the downstream end of catchment 4. CU-08 comprises three barrels and will be constructed at 1.9% grade. A low flow barrel will provide fish passage under all flow conditions. ACU-05 will be constructed to target climbers and be at a grade of 0.5%. ACU-05A and ACU-06 will be constructed along a new stream diversion and will provide connectivity to the upper reaches of sub-catchment 4B. They have grades of 3.1% and 1.1% respectively. CU-08A provides connectivity to an area of intermittent headwaters. CU-09 and CU-12 will be constructed to 3% grade and target climbers. They provides connectivity to a small upper catchment, comprising predominantly intermittent reaches and wetland habitats.	Low

Catchment	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Step 4: Overall effect
				Fish passage is not proposed at three culverts given the limited upstream habitat (CU-11) or high level of modification of the headwaters (CU-10, CU-13).	
Catchment 5	Moderate	Kōura and long fin eel (At Risk Declining) recorded within these catchments, however at this elevation low diversity and minimal habitat very low numbers of fish are expected, indicative of very poor biotic integrity. .	Low	Six culverts are proposed within catchment 5. Only one is in sub-catchment 5A (CU-07). This will be the longest culvert on the Project at 179 m long and will have a grade of 7.2%. The upstream habitat is a combination of permanent and intermittent stream, much of it high value, however it is a relatively short length, particularly considering location in catchment. Much of catchment 5B is being modified and will consist of primarily constructed channel post-development. Fish passage has been prioritised on ACU-03 and CU-04 which connect the residual natural channel in upper 5B with the natural channel downstream of the Project. Climbers are targets and the grades are no more than 5.1%. Fish passage is not proposed at CU-05, CU-06 or ACU-04 due to the limited habitat available following construction.	Low
Catchment 6	Very Low	Only kōura caught (IBI = 0). Assume same as Catchment 5 and longfin may be present.	No effect	No culverts.	No effect

Catchment	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Step 4: Overall effect
Catchment 7	Moderate	IBI of 54 indicative of moderate biotic integrity. Kōura, shortfin and long fin eel (At Risk Declining) recorded within Catchment 7. Barrier at downstream end of catchment (Kiwirail culvert).	Low	Only one culvert is proposed in sub-catchment 7B. CU-03 is partway up the western rise and connects to constructed stream channels with no natural upstream habitat. Notwithstanding, provision has been made to target climbers with embedment of the culvert. All other stream or wetland crossings avoid stream works (i.e. BR03) and therefore will have no impact on fish passage. Kiwirail culvert will be remediated to better facilitate fish passage to this catchment. Further investigation will be conducted during the detailed design phase.	Low
Catchment 8	Low	Highly agricultural catchment. Shortfin eels and common bully recorded but no other species despite low elevation. No threatened species expected to be present. IBI indicative of poor biotic integrity (IBI = 24).	Low	Three culverts within catchment all proposed to be embedded. Grades exceed that for swimming species, but elevated from Manawatū River and located online of constructed stream diversions. CU-01 and CU-02 connect constructed channel but provide no upstream habitat.	Low
Catchment 9	High	IBI of 52, indicative of moderate biotic integrity. Expect a variety of species present within catchment due to connectivity.	No effect	No culverts proposed as part of main works.	No effect

Potential effects of operational stormwater

236. Operational stormwater effects are those related to the changes to the rate and volume ('quantity') and composition ('quality') of water flowing from the road surface during rain events.

237. The proposed stormwater management approach is described in full in the DCR and in Technical Assessment B (Stormwater Management). In brief, the following stormwater design and construction features have been developed to avoid and minimise potential adverse ecological effects.

(a) Water quality treatment of all stormwater runoff from the existing and new State highway within the Project area (to a standard of 75% TSS removal on a long-term average basis) is provided using planted wetlands, wetland swales and swales.

(b) Stormwater erosion effects will be mitigated by:

(i) Provision of detention for all stormwater runoff from the State highway; and

(ii) Provision of rip-rap outfall protection works and rock armouring at all outfalls.

(c) Peak flow attenuation (up to the 10-year annual return period ("**ARI**")[61] storm event) and extended detention in stormwater management systems for all runoff from the State highway. This attenuation will mitigate flooding effects upstream and downstream of the Project.

238. The above stormwater performance standards have been incorporated into the design of the stormwater management devices to treat stormwater from the new highway and cut slopes as follows:

(a) nine stormwater wetlands (W01 to W09);

(b) ten stormwater wetland swales (WS01 to WS10);

(c) ten flow through treatment swales (TS01 to TS07); and

(d) 17 new sediment basins (SB1 to SB17).

[61] An Annual Recurrence Interval (ARI) is the statistical period (number of years) that is predicted will pass before an event of a given magnitude occurs.

239. The location of these devices is shown on the Stormwater Drainage Layout Plans (Drawings TAT-3-DG-H-1401 to TAT-3-DG-H-1421) and Stormwater Management Devices - Catchment Plan (Drawings TAT-3-DG-H-1434).

240. The proposed stormwater management approach is consistent with best practice from the Transport Agency standards[62].

241. The proposed stormwater approach collectively addresses water 'quantity' and 'quality' effects. The following sections describe the potential effects of each of these on aquatic ecology.

<u>Water quantity</u>

242. Potential effects of the Project on hydrology have been addressed by **Dr McConchie** within Technical Assessment D (Hydrology) and within Technical Assessment B (Stormwater Management Design Report). I draw upon that information to inform my assessment of ecological effects. I provide a summary of the effects in the body of my assessment and refer to Table H.16 for catchment level assessment.

243. Increases in impervious surface can change the velocity and volume of stormwater runoff within a catchment, which can result in erosion and habitat modification in streams. Streams are particularly susceptible to erosion during the first flows following rainfall down a catchment which can be managed by detention and slow release of flows.

244. The streams within the Project footprint are generally naturally 'hard bottom', comprising boulders, cobbles and bedrock and falling off steeply towards the Manawatū River. Many of the stream reaches show evidence of incision, a likely result of reduced riparian vegetation and stock damage to stream banks.

245. Streams within the Project area are susceptible to stream bank erosion which can modify in-stream habitat and result in sediment deposition in downstream environments. Measures to mitigate increased flows resulting from the Project are required to reduce the erosion potential.

246. Stormwater wetlands will be designed to detain flows, which will ensure slow release, reducing the potential effects of increased flows on stream systems. At the point of discharge, outfalls will be constructed with erosion protection

---

[62] New Zealand Transport Agency (2010). Stormwater Treatment Standard for State Highway Infrastructure. May 2010.

measures (including energy dissipation structures in some locations) to reduce the potential for erosion.

247. Catchments 5 and 6 will not receive any stormwater runoff from the Project area, with all runoff being directed to wetlands in other catchments. This will result in a decrease in contributing catchment flows within Catchments 5 and 6, and an increase in Catchments 7 and 4.

248. Increases in contributing catchment flows will be minimised through the provision of flow attenuation and extended detention. The receiving environment will not receive any net additional stormwater than it would have in the pre-development condition.

249. There will be a small decrease in contributing catchment at Catchments 5 and 6. The reduction is equivalent only to the area of the State highway as all other catchment area will be retained within the catchment.

250. There will also be a reduction in contributing catchment (and consequently flows) within the eastern reach of sub-catchment 7A. Due to the very small size of this sub-catchment and its high ecological value, further analysis was undertaken. Pre-development flows will be diverted to Wetland 05 at the top of the western reach of sub-catchment 7A. The eastern 7A stream is intermittent, hard bottomed and deeply incised. The post-development scenario results in 40% less contributing catchment at the very top of the stream. At the confluence with the western reach of sub-catchment 7A, the works will represent an 8% reduction in catchment area. Given that this section of stream is intermittent in the headwaters, I consider that the potential change in catchment area to represent a barely discernible change in the underlying characteristics of the tributary.

251. Notwithstanding these changes, the runoff from the Project comprises only a small proportion of the total runoff within the catchments. Further, the existing hydrological environment is highly modified as a result of vegetation clearance and modification. As such, **Dr McConchie** considers within his Technical Assessment that any potential effects will be so small that they could not be identified and quantified.

252. I rely on **Dr McConchie's** assessment in relation to the extent of change expected in the freshwater environment. I consider that the magnitude of effect after mitigation measures are imposed will be Low for all catchments, except the Manawatū River, where it will be Negligible.

Water quality

253. Potential effects of the Project on water quality have been addressed by **Mr Hughes** within Technical Assessment B (Stormwater Management) and **Mr Hamill** in Technical Assessment C (Water Quality). I draw upon that information to inform my assessment of ecological effects. I provide a summary of the effects in the body of my assessment and refer to Table H.16 for catchment level assessment.

254. Stormwater runoff from roads can contain a wide range of contaminants including most often, heavy metals, hydrocarbons and TSS. These contaminants entrained in stormwater runoff have the potential to impact fauna and ecosystem health within the freshwater environment. Thermal pollution, resulting from increased impervious surfaces or stormwater treatment devices themselves, is an additional potential impact of stormwater operation.

255. Many of the stream systems within the Project area show evidence of existing water quality degradation with macroinvertebrate indices generally indicative of poor or fair water quality and less than the target of 100 in the One Plan Schedule E (Table H.9). Areas of higher macroinvertebrate indices are those that would be more sensitive to changes in water quality resulting from stormwater runoff.

256. Stormwater treatment devices are designed to attenuate stormwater runoff and encourage suspended sediments to drop out of suspension. Many contaminants bind to sediment and those contaminants remain in the stormwater device and treated water is discharged to the environment.

257. The proposed approach to stormwater treatment is referred to as a 'treatment train' which includes a series of devices to improve the quality of stormwater runoff. This includes 'at-source' catchpit devices for gross pollutants, planted or rocklined swales for capture and conveyance of stormwater runoff and planted wetlands as the primary treatment device prior to discharge.

258. All stormwater runoff is proposed to be treated, which includes more than just the first flush (which is accepted as having the highest concentration of contaminants during a rain event). The proposed treatment scenario is an improvement on existing situation where no formal treatment of stormwater runoff from existing State highway roads[63] within the Project area is provided.

[63] This includes existing roads at the Woodville (Fitzherbert East Road (SH57) and Napier Road (SH3)) and Ashurst roundabouts (Woodlands Road, Napier Road and Vogel Street (SH3)).

259. **Mr Hamill** undertook modelling to estimate the potential changes within the receiving environment. The key conclusions from his assessment are described as follows:

(a) Overall, the analysis shows a net reduction in the load of stormwater contaminants to the Manawatū River downstream of the Project.

(b) The load of stormwater contaminants will reduce in the Pohangina River, and Catchments 1, 2, 4 and 9.

(c) Stormwater will not be discharged into Catchments 5 and 6. Rather these flows will be diverted to wetlands in other catchments. As such, there will be no stormwater quality effects on these catchments.

(d) Sub-catchment 2E, and Catchments 3, 7 and 8 will have a net increase in stormwater contaminant loads. However, the concentration of contaminants assessed will result in only small effects as the discharges will be intermittent in nature and the TSS concentration will be similar to that currently found in streams during high flows. Further, all contaminants will be within the ANZG[64] guidelines for protection of 95% of species.

260. The potential magnitude of effect from thermal pollution has been assessed by **Mr Hamill** as very small. This is because no more than 5% of any affected catchments will be impervious and the proposed stormwater treatment devices can be designed to alleviate potential temperature effects. For example, wetlands with 80% vegetated cover can sufficiently shade the water to mitigate thermal effects.[65]

261. **Mr Hamill** concludes that most of the time and during baseflow conditions, stormwater quality can be expected to have a 'negligible or minor' impact on stream water quality. I concur with his assessment and under the EcIAG consider that the magnitude of effect (with treatment devices being in place) is no more than a Low level of effect for all catchments, except catchment 7.

262. The implementation of the proposed stormwater quantity and quality controls results in an overall ecological effect of Very Low to Low (all presented in Table H.16).

[64] ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines

[65] Young D, Afoa E, Meijer K, Wagenhoff A, Utech C (2013). Temperature as a contaminant in streams in the Auckland region, stormwater issues and management options. Prepared by Morphum Environmental Ltd for Auckland Council. Auckland Council technical report, TR2013/044

Table H.16: Overall effect of operational stormwater on water quantity and quality after mitigation.

Catchment	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Step 4: Overall effect
Manawatū River	High	Nine species of native fish present in the catchment including three At Risk Declining species. IBI (78) indicative of excellent biotic integrity. Manawatū River is recognised as a trout fishery (non-ecological value). Part of a wider catchment with levels of degradation resulting from agricultural land use. Elevated levels of suspended sediments present in systems during flood currently.	Negligible (improvement over baseline for water quality)	Wetland W02 discharges directly to Manawatū River. Scale of project relative to river is small. Unlikely to be discernible change or small improvement in water quality at Manawatū River as runoff from existing roads not treated. Negligible change in hydrology at this scale.	Very Low (positive effect for water quality)
Catchment 1	Low	Highly modified watercourses with poor diversity and abundance of fauna. Current SEV score (SEVi-C) 0.32 indicative of very low ecological function. Limited upstream catchment and nutrient enrichment evident. Existing road crossings and modification of flow regime. Riparian margin absent. Macroinvertebrate indices indicative of poor water and habitat quality (MCI_sb = 63, QMCI_sb = 3.24, %EPT abundance = 0.00) and very poor fish biotic integrity (IBI = 24). Existing stream channels modified and straightened, appear to be subject to regular maintenance.	Low (improvement over baseline for water quality)	Wetland swales. Post-development level of contaminants in the environment will be lower than pre-development.	Very Low
Catchment 2	High	Watercourses affected by agricultural land use, stock access to streams. Headwaters of 2C higher value with relatively intact riparian margins and hard bottom substrates. Remainder of affected streams lower current value. SEVi-C scores representative of very low to very high ecological function (n=6; 0.29 – 0.79).	Low (improvement over baseline for water quality at a catchment level)	Wetlands W08 and W09. Stormwater diverted to treatment devices, detention and attenuation provided. Post-development level of contaminants in the catchment will be lower than pre-development.	Low

Catchment	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Step 4: Overall effect
		Macroinvertebrate indices indicative of localised habitat and water quality issues. Highest in hard bottom upper catchment with restricted stock access (MCI = 104; 80, QMCI = 5.54; 4.12, % EPT abundance 32.88; 2.31). Lower reaches and headwaters of 2E indicative of poor water and habitat quality (MCI_sb = 60; 67; 70; 78, QMCI_sb = 2.69; 2.66; 2.61; 2.34, %EPT abundance = 1.96; 7.11; 0.46; 0.00) Lowland reaches of Mangamanaia Stream have excellent fish biotic integrity (IBI = 70), however steeper reaches expect to have lower diversity of fish due to reduced habitat availability and access restrictions (IBI estimated to be 24, 'very poor').		Specifically within sub-catchment 2E there is an anticipated increase in loads, however concentrations of contaminants will be within guideline values. Changes in hydrology unlikely to affect freshwater ecology at catchment scale. Some small changes anticipated at reach scale in sub-catchment 2C and 2E.	
Catchment 3	Moderate	Steep short catchment, with two main sub-catchments. Moderate value wetland upstream of potential stormwater impacts on sub-catchment 3A. Post development, limited upstream catchment. Riparian margin absent along lower reaches, present in parts in upper catchments. Current SEV score (SEVi-C) 0.38, 0.66 indicative of low to moderate ecological function. Macroinvertebrate indices indicative of poor water and habitat quality (MCI_sb = 67, QMCI_sb = 2.15, %EPT abundance = 0.99; MCI=89, QMCI = 4.03, %EPT abundance = 7.83) and moderate fish biotic integrity (IBI = 52).	Low	Wetland W07. Attenuation and detention at head of each sub catchment. There is an anticipated increase in loads, however concentrations of contaminants will be within guideline values. Macroinvertebrate indices indicative of tolerant species, unlikely to respond to water quality change. Changes in hydrology unlikely to affect freshwater ecology at catchment or sub-catchment scale.	Low
Catchment 4	Moderate	Watercourses affected by agricultural land use, stock access to streams. Gully systems with wetland habitats present. Remainder of affected streams lower current value.	Low (improvement over baseline for water quality)	Wetland swales and Wetland W06. Post-development level of contaminants in the environment	Low

Catchment	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Step 4: Overall effect
		SEVi-C scores representative of moderate ecological function (n=5; 0.40 – 0.56). Macroinvertebrate indices indicative of localised habitat and water quality issues. Highest in hard bottom upper catchment with restricted stock access (MCI and MCI-sb= 64 to 88, QMCI = 2.19 to 4.32, % EPT abundance 0 to 8.64). Fish IBI 34, indicative of very poor, but healthy population of upland bully present in catchment.		will be lower than pre-development.	
Catchment 5	High	Steep, hard bottom stream systems in agricultural land use with fragmented riparian margins. Some existing sediment deposition, however cobbles and gravels provide habitat heterogeneity. Macroinvertebrate indices highest of affected catchments, indicative of good and excellent water and habitat quality (up to MCI = 120). Moderate fish biotic integrity (48). SEV scores indicative of good to excellent ecological function (0.5 to 0.76).	Low	Stormwater will not be discharged into the catchment, therefore avoiding any water quality effects. Minor change in contributing catchment however unlikely to affect downstream reaches.	Low
Catchment 6	High	Only kōura caught (IBI = 0). Assume same as Catchment 5 and longfin may be present. QEII protection over much of catchment. Riparian margins relatively intact, cobble bottom stream.	Low	Minor change in contributing catchment. Stormwater will not be discharged into the catchment, therefore avoiding any water quality affects. Some runoff down cutoff drains but marginal. Potential change unlikely to be discernible within the upper stream reaches.	Low
Catchment 7	High	Consists of three sub-catchments, two potentially affected by stormwater. Fish index of biotic integrity indicative of moderate value (54). 7A higher value, with intact riparian margins, fencing and good in-stream macroinvertebrate values. Some	Low	Wetlands W03, W04, W05 and treatment swales. At catchment scale, anticipate the change will be barely discernible therefore Low.	Low

Catchment	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Step 4: Overall effect
		sections of stream exhibit depositional areas, however predominantly a steep catchment. SEV values indicative of good to high value stream systems (0.50, 0.78). Macroinvertebrate indices reflect good to excellent water quality and habitat values, including in pasture headwaters. Sensitive EPT taxa present in headwaters (up to 44% EPT abundance). 7B of lower current value in agricultural land, minimal margins and stock access unrestricted. Macroinvertebrate indices and reflective of poor water quality and degraded habitat. SEV scores moderate, 0.44 to 0.7.		There is an anticipated increase in loads, however concentrations of contaminants will be within guideline values. Macroinvertebrate indices near upper catchment (where discharge least diluted) indicative of 'good' current water and habitat quality. Notwithstanding, the 95% protection guideline is considered appropriate. Modification of flow regime at headwaters with increased flow to western branch of upper 7A, and reduced flow to eastern 7A branch. Assessment undertaken determined effect commensurate with a barely discernible change. Detention and attenuation in wetland will reduce potential effects of flow on western 7A.	
Catchment 8	Low	Highly modified, agricultural catchment. IBI indicative of poor biotic integrity (IBI = 24). Evidence of regular channel clearance for maintenance. SEV score indicative of poorly functioning ecosystem (0.31), and macroinvertebrates confirm degraded state (MCIsb = 66).	Low	Wetland W01 and treatment swales. There is an anticipated increase in loads, however concentrations of contaminants will be within guideline values. Macroinvertebrate indices indicative of very tolerant species unlikely to respond to water quality change.	Very Low

Catchment	Step 1: Ecological value	Reason for value	Step 2: Magnitude of effect (after mitigation)	Reason for magnitude following mitigation	Step 4: Overall effect
Catchment 9	High	Anticipate high value based on shading and riparian vegetation within gully systems. IBI of 52, indicative of moderate biotic integrity. Expect a variety of species present within catchment due to connectivity.	Low (improvement over baseline for water quality)	Minimal amount of flow being directed into catchment. Post-development level of contaminants in the environment will be lower than pre-development.	Low

Modification or loss of stream habitat

263. The Project traverses nine catchments and transects gully and stream systems. Culverts will be installed to enable streams to continue to flow downstream of the alignment. Due to the topography of the site, road embankments will also encroach onto stream systems. Further the Project will generate spoil and material that requires disposal into gully systems onsite. These activities will result in the loss of stream ecological function and values.

264. A total of 13.365 km of stream length (permanent and intermittent) will be affected by the Project. This has been calculated by GIS analysis and based on all stream length located under the Project footprint plus a buffer[66] to allow for construction activities.

265. 33 culverts will be constructed across the alignment comprising main road and access road culverts.

266. A substantial portion of impacted stream length will be located underneath spoil sites or road embankments. Much of this stream length will be replaced with stream diversions comprising 3 types:[67]

(a) Type 1 - permanent streams with low gradient;

(b) Type 2 - permanent streams with steep gradient; and

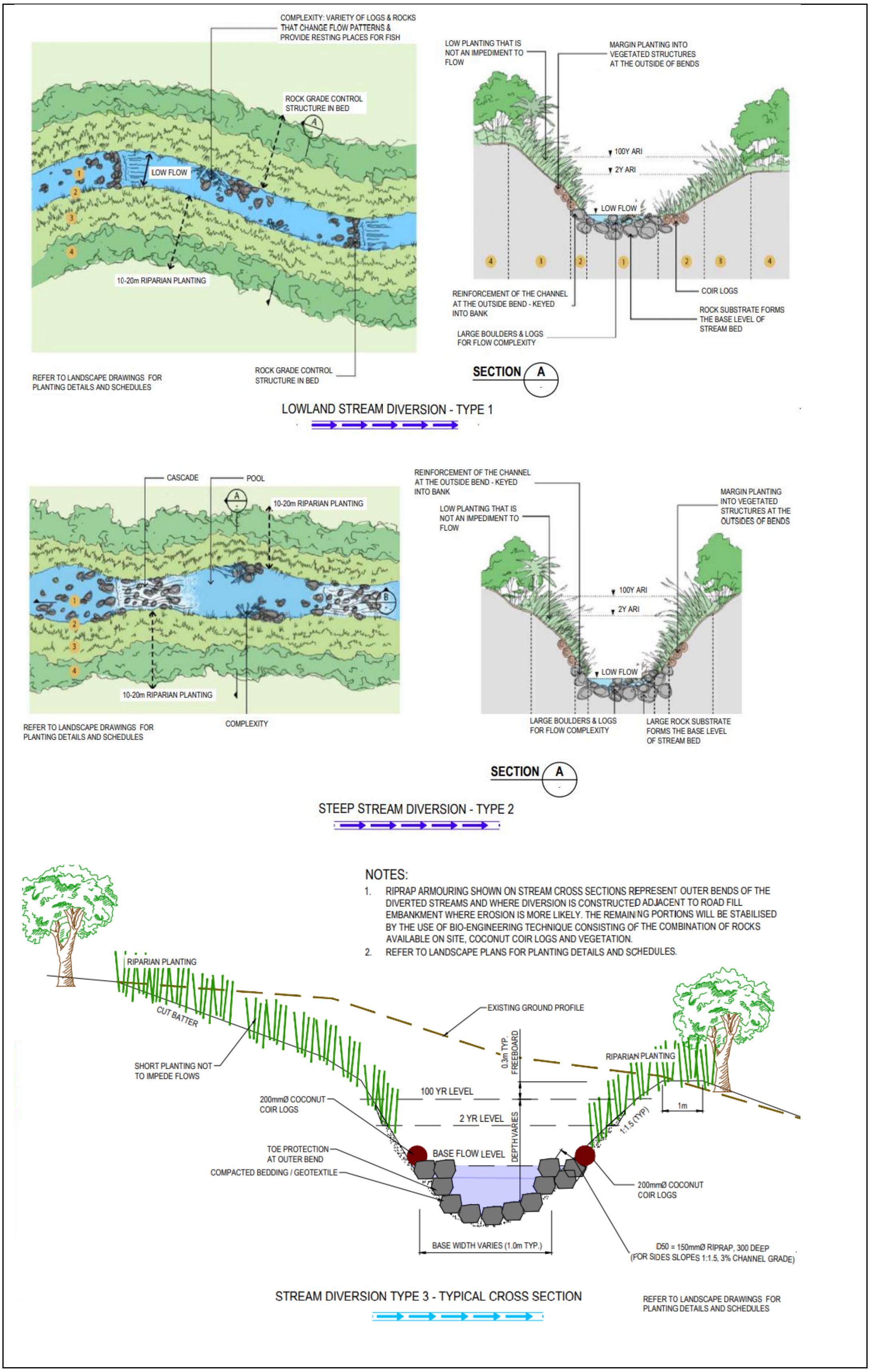
(c) Type 3 - intermittent stream diversions.

267. Proposed design details are provided in a Diversion Schedule (refer to Technical Assessment B (Stormwater Management Design Report) Appendix B.2). Typical details for each of the diversion types are shown on the Typical Stormwater Drainage Details Stream Diversions and Cut-Off Drains (Drawing TAT-3-DG-H-1451) and summarised in Figure H.5 below.

268. While some of the effects can be mitigated, for example by ensuring fish passage through culverts, the residual impact to the stream ecological function and values represents a Very High magnitude of ecological effect. In contrast to the other types of effects considered in this assessment, this level of impact cannot be mitigated, and instead needs to be offset or compensated.

[66] This buffer is described in the DCR and the AEE, and it varies from 7 m to 20 m depending on location.
[67] In addition, cut off drains will be constructed along the base of cut faces and embankments. These are referred to as 'Type 4' diversions and are not considered to contribute to a post-construction ecological benefit and so are not discussed further in this assessment.

Figure H.5: Stream Diversion Design Details Type 1 (top), Type 2 (middle), Type 3 (bottom). Source: Drawing TAT-3_DG-H-1451-C.



Offsetting and no net loss for impacts on stream habitat

269. Offsetting is 'a measurable conservation outcome resulting from actions designed to compensate for residual adverse biodiversity effects arising from activities after appropriate avoidance, remediation, and mitigation measures have been applied'.[68] To be considered an offset, the resulting conservation outcomes or 'gains' should be consistent with a set of offsetting principles, including the goal of 'no net loss' described above.

270. Within this assessment, the 'gains' are proposed to be achieved through stream diversions (creation of new stream habitat), together with riparian planting of gully systems.

271. As described in [104] to [115] SEV scores have been assigned to 'loss' and ''gain' reaches to inform the calculation of the ECR. These are provided in APPENDIX H.4: Summary Reach Based ECR Calculations and summarised on a catchment basis in Table H.17 below. These effects are presented in the context of the EcIAG in Table H.18.

Table H.17: Summary of proposed offset and range of ECR calculated for each catchment.

Catchment	Streambed area impacted (m^2) ('loss')	Proposed offset measures ('gain')	ECR range
Catchment 1	974	1,102 m^2 streambed enhancement via riparian planting 700 m^2 new stream creation	1.09 to 2.23
Catchment 2	1690	2,831 m^2 streambed enhancement via riparian planting 1,492 m^2 new stream creation	1.28 to 4.41
Catchment 3	181	346 m^2 streambed enhancement via riparian planting 102 m^2 new stream creation	1.98 to 5.36
Catchment 4	2583	3370 m^2 streambed enhancement via riparian planting 2971 m^2 new stream creation	1.37 to 5.09
Catchment 5	1349	2,010 m^2 streambed enhancement via riparian planting 1,692 m^2 new stream creation	2.10 to 4.34
Catchment 6	39	119 m^2 streambed enhancement via riparian planting	2.96 to 3.53
Catchment 7	639	172 m^2 streambed enhancement via riparian planting 1,410 m^2 new stream creation	1.97 to 2.89
Catchment 8	794	1,133 m^2 new stream creation	1.01 to 2.06

[68] Maseyk et al (n 35).

Catchment	Streambed area impacted (m^2) ('loss')	Proposed offset measures ('gain')	ECR range
Catchment 9	55	161 m^2 streambed enhancement via riparian planting	2.96

272. ECRs between 1.09 and 5.36 were calculated depending on the ecological value lost at the impact site, and the potential ecological gain at the offset site. On average, an ECR of 2.48 has been calculated as being required to offset the effects of the Project on streams. This quantum of offset is similar to that offered by other projects, particularly when considering the benefit the diversions offer at a catchment scale.

273. The quantum of new stream creation, and streambed enhancement (via riparian planting), is presented by catchment in Table H.17.

274. A total area of 9,500 m^2 streambed created through the construction of stream diversions is considered to provide ecological benefit and is included in the offset calculations. The total stream bed area being created for the Project is estimated to be 11,429 m^2, representing approximately 1,900 m^2 additional stream bed being created but not quantified within the no net loss calculations.

275. In addition to the diversions being created riparian planting is proposed. Riparian enhancement planting along 10,137 m^2 streambed area within Ratahiwi Farm has been calculated as being required to achieve no net loss.[69] The Ratahiwi Farm site has been identified as one of several sites within proximity to the Project which may be suitable for undertaking riparian planting. The riparian planting proposed to offset the effects is discussed in more detail from [285] below.

276. Overall, these actions will result in a no net loss in ecological function, according to the SEV and ECR method, across the Project. Performance standards to measure the success of the proposed offset measures will be incorporated into the EMP, specifically in the Planting Establishment Management Plan ("**PEMP**") and FEMP.

277. The SEV and ECR method provide a means to establishing whether the offsetting principle of no net loss has been achieved, but it does not of itself address the remainder of the offsetting principles. These are described in the sections following for each of stream diversions and riparian planting.

[69] Again, these figures use Ratahiwi Farm as an indicative location for riparian restoration.

Stream diversions and offsetting principles

278. The benefits of the creation of stream diversions in the context of this Project is twofold. The diversions facilitate the movement of water along a similar path to predevelopment and in that respect, they mitigate potential effects on catchment flow regimes. However, the diversions also offer the potential to provide ecological habitat if they are designed and constructed adequately. Stream diversions are shown on the Stormwater Drainage Layout Plan Drawings (TAT-3-DG-H-1401 to 1421).

279. Stream diversions can be difficult to construct and are typically viewed as having uncertain outcomes due to the features inherently required to maintain the stream channel (without risk of it downgrading). Where a diversion has upstream habitat, it is more likely to be successful, as a source of periphyton/biofilms, substrates, macroinvertebrates and organic matter.

280. Conversely, where a diversion results from a vertical realignment,[70] the connectivity of the stream with groundwater is modified and the ecological function of the hyporheic zone can be affected.

281. Notwithstanding this each diversion should be assessed on its merits and recognised for the ecological benefits beyond that offered by riparian planting or other offset measures. The potential ecological function of these diversions has been assessed with recognition of the limitations of modelling works of this nature and the ecological benefits offered. Specifically, stream diversions provide additional habitat and stream length to replace that being lost. While the diversion may not have the exact values of a natural channel, the net loss of available habitat/length is addressed by provision of the constructed habitat.

282. At a catchment level, stream diversions mitigate the overall effect of habitat modification. That is, in catchments where there is a net gain in stream length, some of the effects of stream habitat modification may be mitigated. In this assessment the diversions contribute to offsetting the effects of streambed habitat modification.

283. In the context of offsetting principles, the following applies:

    (a) Stream diversions result in new stream habitat being created, which contributes to reducing the overall net length lost at a Project scale.

[70] A vertical realignment refers to a situation where a stream gully is filled and a new stream is constructed on top of the filling material. That is, it has been 'vertically realigned'.

The stream diversions are proposed to mimic the existing environment and so meet the principle of like for like;

(b) The diversions are located adjacent to or within the same catchment as the impact streams and so meet the principle of proximity;

(c) The stream diversions are being constructed to provide stream habitat and in that, they meet the principle of additionality;

(d) Meaningful ecological benefit must be considered in the context of the diversion being created. Some of the diversions will have a better ecological outcome than others, but the relative value of that is estimated through use of the ECR; and

(e) No net loss of ecological function has been demonstrated through the use of the SEV and ECR.

284. For those residual adverse effects that cannot be addressed by the stream diversions, riparian planting and fencing is proposed at a site outside of the proposed designations.

Riparian restoration and offsetting principles

285. Riparian restoration and enhancement is a fairly well established method for improving the quality of aquatic systems. Riparian restoration and enhancement planting is proposed to be undertaken to address residual effects on freshwater ecology resulting from the Project.

286. The role of riparian vegetation is pivotal to maintaining stream ecosystem functions. Riparian vegetation, depending on the width and composition, can contribute to:[71]

(a) Reducing stream temperature fluctuations by providing shade vital for aquatic fauna survival and to suppress the growth of macrophytes (oxygen-demanding);

---

[71] Holmes, R., Hayes, J., Matthaei, C., Closs, G., Williams, M., and Goodwin, E. (2016). Riparian management affects instream habitat condition in a dairy stream catchment. New Zealand Journal of Marine and Freshwater Research 50 (4), 581 – 599
Parkyn, S., Shaw, W., and Eades, P. (2000). Review of information on riparian buffer widths necessary to support sustainable vegetation and meet aquatic functions. Prepared by NIWA for Auckland Regional Council. Auckland Regional Council Technical Publication Number 350, 38 pages
Quinn, J. M., Williamson, R. B., Smith, R. K., and Vickers, M. L. (1992). Effects of riparian grazing and channelization of streams in Southland, New Zealand. 2. Benthic invertebrates. New Zealand Journal of Marine and Freshwater Research 26, 259 – 273
Auckland Regional Council (2001). Strategy guideline, planting guide riparian zone management. Technical Publication 148.

(b) Influencing the hydraulic energy input into the stream (controlling the amount and fluctuations);

(c) Influencing the chemical energy input and transfer (tree root and woody material interaction);

(d) Stream bank and channel stability;

(e) Maintaining water quality by reducing nutrient and sediment inputs (riparian vegetation filtering of surface water runoff); and

(f) Providing in-stream habitat for aquatic fauna (i.e. fallen large woody material and tree root) as well as terrestrial fauna (e.g. birds, lizards, insects, bats etc).

287. The composition of the riparian margin is important as it links stream and terrestrial systems through the contribution of woody debris, nutrient transfer, root zone connectivity, and overhanging plants to support native fish spawning habitat. In the SEV methodology, mature native vegetation is considered to have higher ecological value than most other vegetation complexes.

288. Livestock exclusion from streams provides benefits beyond decreasing direct sediment runoff from livestock trampling. Fencing provides improvements on multiple aspects at reach-level such as supporting riparian vegetation development, which in turn provides shading, increases biodiversity, and creates habitat for terrestrial fauna. Even without riparian planting, rank grass that can establish in the absence of grazing can filter overland runoff, removes the direct input of animal waste to streams and enables banks to stabilise.

289. It is proposed to plant and retire stream margins within the immediate Project catchments to provide for improved aquatic ecosystem health. This will include fencing of riparian margins to restrict stock access and planting of these margins, currently modelled to a width of 20 m on each bank.

<u>Indicative sites: Ratahiwi Farm and Sproull Farm</u>

290. Several landowners have expressed an interest in having their streams fenced and planted. These sites are along the Manawatū River and many have stream margins which are unvegetated and would benefit from riparian planting and stock exclusion. These sites will be further considered as the final offset package is developed.

291. For the purposes of this assessment, it is assumed that one or more sites proximate to the Project will be available. Two sites have been surveyed to provide initial indications of potential 'gains' within the catchment. These are:

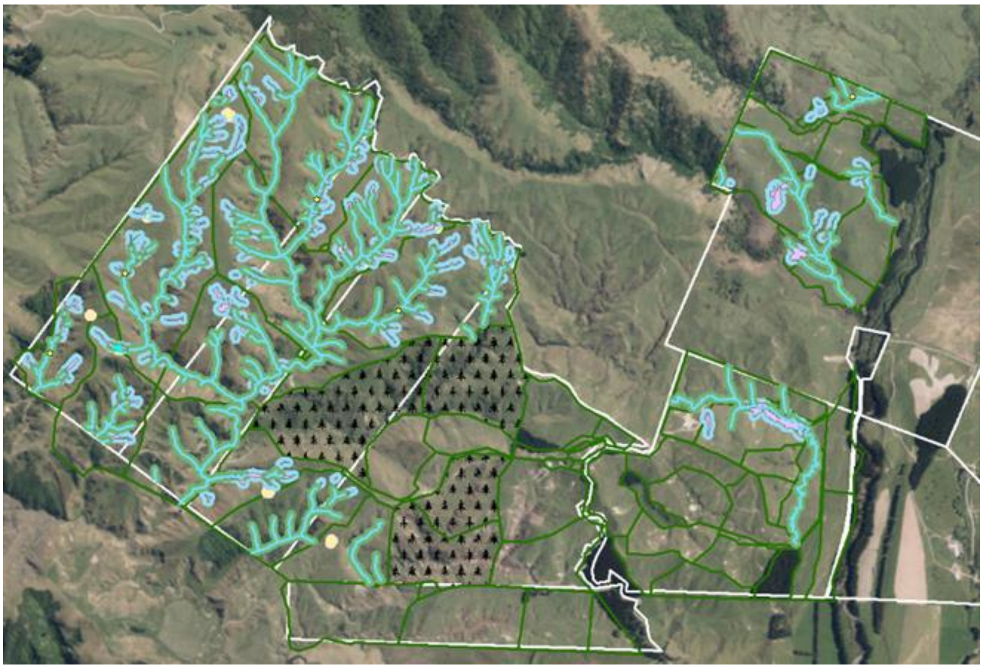
(a) Ratahiwi Farm, as discussed above; and

(b) Sproull Farm.

292. There have been very recent discussions with these landowners and others in proximity to the Project. As such, the final location of offset (both within the Farms identified in this assessment and with other landowners) will be developed through further discussion. For the purposes of this assessment, the majority of the offset has been calculated based on the values obtained from the Ratahiwi Farm. Since initial engagement with the landowners, the extent of possible enhancement has been more clearly identified, with that more clearly identified stream length reflected in the Proposed Ecological Offset/Compensation Drawings (TAT-3-DG-E-4161 and TAT-3-DG-E-4162).

293. However, for the purposes of this assessment, and to determine whether the actual and potential effects of the Project on freshwater habitats can be managed, streams have been walked and SEV modelling has been applied to streams on Ratahiwi Farm as shown on Figure H.6. I note that Figure H.6 identifies more stream length (in the order of 23 km) than is shown on the Proposed Ecological Offset/Compensation Drawings (in the order of 17 km at Ratahiwi Farm). The ecological 'gains' shown on Figure H.6 are considered to be representative of the types of stream enhancement measures that could occur on other sites and so are used to inform an indicative offset package. The potential extent of riparian planting and enhancement is shown on the Proposed Ecological Offset/Compensation Drawings (TAT-3-DG-E-4161 and TAT-3-DG-E-4162).

Figure H.6: Potential offset streams in upper Mangamanaia catchment located within the Ratahiwi Farm. Map shows streams (blue lines), wetlands (purple) and ponds (yellow), each with a 20 m riparian buffer (green, blue and beige, respectively). Pine tree images are being planted for under other projects. Note that the actual extent of what contributes to the offset package will be confirmed as details around the available stream and landowner preferences are further developed.



294. To achieve greater ecological benefits, degraded streams at a catchment-level scale - like the Ratahiwi Farm site - will be preferred and prioritised for enhancement and restoration actions. Degraded stream systems, for instance, are characteristic of rural catchments with unrestricted stock-access and minimal existing riparian vegetation or overgrown with exotic weed or pest plant species. The proposed planting will involve retirement and restoration of riparian margins along gully waterways, with the SEV calculations carried out for this assessment assuming an average width of 20 m from each bank.

295. Catchment scale enhancement has a greater influence on ecosystem function compared to many small-scale enhancement efforts.[72] Where reach scale efforts can result in shade across the stream cross section, 1 km of planting where 75% shade is achieved can result in an in-stream temperature reduction of 5^{o}C.[73] Therefore, there are benefits to wider catchments when headwaters are planted. Similarly, while a riparian buffer can filter runoff from a single

[72] Doehring, K., Clapcott, J. E., and Young, R. G. (2019). Assessing the functional response to streamside fencing of pastoral Waikato streams, New Zealand. Water 11, 1-22
[73] Collier, K.J., Cooper, A.B., Davies-Colley, R.J., Rutherford, J.C., Smith, C.M., and Williamson, R. B. (1995). Managing riparian zones: a contribution to protecting New Zealand's rivers and streams. Vol 2. Department of Conservation.

paddock, water quality within the stream is affected by activities beyond the immediate enhancement area. As such it is considered that enhancement across a wider catchment or enhancement that improves landscape connectivity will provide higher ecological benefit than reach scale only. These are additional benefits, not specifically captured in the SEV assessment method or ECR offset accounting framework.

296. The Sproull Farm site is located on the southern side of the Manawatū River and is another site available to contribute to an offset package. Up to 6 km of additional stream length is available for enhancement here. These streams have been walked and SEV undertaken, but for the purposes of this assessment, the potential ecological benefits of this additional stream length have not been calculated using the ECR. Based on data obtained, I consider that there is good potential for enhancement at these sites and the enhancement of them would contribute to the overall management of effects on stream systems, should it prove necessary to utilise this area.

<u>Offsetting principles applied to the proposed riparian restoration</u>

297. In the context of offsetting principles, the following applies to the proposed riparian restoration and enhancement planting:

(a) Stream enhancement results in an improvement to habitat that is ecologically equivalent to that being impacted, so meeting the principle of like for like.

(b) The enhancement works would not otherwise be undertaken, so the works are additional.

(c) The enhancement is at a gully scale demonstrating ecological benefit, and has been quantified as providing no net loss of ecological function.

(d) The enhancement is within the impact catchment, and discharges upstream of the main impacts. Therefore the principle of proximity is met and the ecological benefits will be measurable within the impact catchment.

(e) There are benefits beyond those measured using the accounting framework, including reduction in nutrients, temperature and water quality improvements at a large scale, reduction in sedimentation, connecting existing ecosystems to improve corridors, which has benefits for terrestrial fauna as well.

Conclusion

298. Stream habitat loss and modification is the most significant effect on freshwater ecology associated with this Project. All efforts to avoid and minimise effects have been explored and unavoidable, residual effects have been addressed. While the overall level of effect remains Very High, the effects of the Project can be offset to achieve no net loss in ecological function, through the creation of stream diversions and riparian enhancement.

299. I consider that the principles of offsetting can be met, recognising that my assessment is tied to western scientific assessment of freshwater ecology and I am not in a position to comment on whether traditional knowledge has been sufficiently incorporated. The proposed offset package has been developed following discussions with representatives of DOC and iwi Project partners.

300. At the time of writing, a quantum of stream creation (through diversions) and riparian restoration and enhancement planting had been calculated to offset the residual effects resulting from stream loss or modification. It is demonstrated that no net loss in ecological function can be achieved.

301. The final composition of the offset package will be determined following further discussions with landowners and following further design refinement. The offset package to address residual effects on stream habitat will be finalised using the ECR methodology and comprising construction of the proposed Type 1, 2 and 3 stream diversions and riparian planting and fencing of intermittent and permanent streams within the vicinity of the Project. I consider that the measures proposed are sufficient to address the residual freshwater ecology effects associated with this Project, and will result in a positive overall outcome within the immediate Manawatū River catchment.

Table H.18: Overall effect from stream loss or modification.

<table>
<tr><th>Catchment</th><th>Step 1: Ecological value</th><th>Reason for value including consideration of potential value</th><th>Step 2: Magnitude of effect</th><th>Reason for magnitude / overall effect following measures to offset effects, with relevant stream diversions and riparian planting detailed in Table H.17.</th><th>Step 4: Overall effect</th></tr>
<tr><td>Manawatū River</td><td>High</td><td></td><td>Negligible</td><td>Permanent modification is isolated to one pier and will be under the riverbed. While the pier will be visible, there will only be a very slight change from the existing baseline condition.
Mitigated.</td><td>Very Low</td></tr>
<tr><td>Catchment 1</td><td>Low</td><td>Highly modified watercourses with poor diversity and paucity of fauna.
Current SEV score (SEVi-C) 0.32 indicative of very low ecological function. Potential value of the streams limited by the agricultural land use and extent of modification to the stream channels (SEVi-P = 0.68).
Limited upstream catchment and nutrient enrichment evident. Existing road crossings and modification of flow regime. Riparian margin absent.
Macroinvertebrate indices indicative of poor water and habitat quality (MCI_sb = 63, QMCI_sb = 3.24, no EPT taxa) and very poor fish biotic integrity (IBI = 24).</td><td>Very High</td><td>Combined impact length of 923 m stream in catchments 1A and 1B (as per table below).
Combined 1023 m Type 1 and Type 3 stream diversion being created.
Stream diversions being created near to natural ground level, however formed into embankments adjacent to road edge. Limits to ecological value of the diversions following construction.
Overall, more stream length within this catchment post-construction.
<table><tr><th>Catchment</th><th>Length (m)</th><th>Area (m2)</th></tr><tr><td>1</td><td>923</td><td>974</td></tr><tr><td>1A</td><td>561</td><td>299</td></tr><tr><td>1B</td><td>362</td><td>675</td></tr></table></td><td>Moderate; will be offset to achieve no net loss in ecological function.</td></tr>
<tr><td>Catchment 2</td><td>High</td><td>Watercourses affected by agricultural land use, stock access to streams. Headwaters of 2C higher value with relatively intact riparian margins and hard bottom substrates. Remainder of affected streams lower current value.
SEVi-C scores representative of very low to very high ecological function (n=6; 0.29 – 0.79). Potential for enhancement excellent</td><td>Very High</td><td>Approximately 80 lineal metres of Mangamanaia Stream being modified to install rip-rap below proposed BR07. Temporary impacts, however post construction, assume that ecological function comparable to pre-development.
Combined length of 2808 m being permanently impacted in Catchment 2 (across 2B, 2C and 2E) (as per table below).</td><td>Very High; will be offset to achieve no net loss in ecological function.</td></tr>
</table>

<table>
<tr><th>Catchment</th><th>Step 1: Ecological value</th><th>Reason for value including consideration of potential value</th><th>Step 2: Magnitude of effect</th><th>Reason for magnitude / overall effect following measures to offset effects, with relevant stream diversions and riparian planting detailed in Table H.17.</th><th>Step 4: Overall effect</th></tr>
<tr><td></td><td></td><td>due to topography of streams and headwaters protected from agricultural land use (SEVi-P 0.54 – 0.91).
Macroinvertebrate indices indicative of localised habitat and water quality issues. Highest in hard bottom upper catchment with restricted stock access (MCI = 104; 80, QMCI = 5.54; 4.12, % EPT abundance 32.88; 2.31). Lower reaches and headwaters of 2E indicative of poor water and habitat quality (MCI_sb = 60; 67; 70; 78, QMCI_sb = 2.69; 2.66; 2.61; 2.34, %EPT abundance = 1.96; 7.11; 0.46; 0.00)
Lowland reaches of Mangamanaia Stream have excellent fish biotic integrity (IBI = 70), however steeper reaches expect to have lower diversity of fish due to reduced habitat availability and access restrictions (IBI estimated to be 24, 'very poor').</td><td></td><td>All of tributary 2C8 will be located under the road alignment. Catchment flows diverted into two diversions on either side of the road embankments. Constructed habitat vertically realigned into engineered material.
Headwaters of 2E will be located under Spoil Site 31.
New stream diversions being created to provide 1114 m of Type 2 and 1 habitat.
<table><tr><th>Catchment</th><th>Length (m)</th><th>Area (m2)</th></tr><tr><td>2</td><td>2808</td><td>1691</td></tr><tr><td>2A</td><td>242</td><td>403</td></tr><tr><td>2B</td><td>171</td><td>286</td></tr><tr><td>2C</td><td>1047</td><td>424</td></tr><tr><td>2E</td><td>1348</td><td>577</td></tr></table></td><td></td></tr>
<tr><td>Catchment 3</td><td>High</td><td>Steep short catchment, with two main sub-catchments. Moderate value wetland upstream of potential stormwater impacts on sub-catchment 3A.
Current SEV score (SEVi-C) 0.38, 0.66 indicative of low to moderate ecological function but excellent potential for enhancement (SEVi-P = 0.73, 0.91).
Macroinvertebrate indices indicative of poor water and habitat quality (MCI_sb = 67, QMCI_sb = 2.15, %EPT abundance = 0.99; MCI=89, QMCI = 4.03, %EPT abundance =</td><td>Very High</td><td>Combined 724 m stream being impacted in the headwaters of catchment 3A and 3B (as per table below).
One Type 3 diversion of 111m being created within Catchment 3B.
<table><tr><th>Catchment</th><th>Length (m)</th><th>Area (m2)</th></tr><tr><td>3</td><td>724</td><td>182</td></tr><tr><td>3A</td><td>303</td><td>94</td></tr><tr><td>3B</td><td>422</td><td>88</td></tr></table></td><td>Very High; will be offset to achieve no net loss in ecological function.</td></tr>
</table>

Catchment	Step 1: Ecological value	Reason for value including consideration of potential value	Step 2: Magnitude of effect	Reason for magnitude / overall effect following measures to offset effects, with relevant stream diversions and riparian planting detailed in Table H.17.	Step 4: Overall effect
		7.83) and moderate fish biotic integrity (IBI = 52).			
Catchment 4	High	Watercourses affected by agricultural land use, stock access to streams. Gully systems with wetland habitats present. Remainder of affected streams lower current value. SEVi-C scores representative of moderate ecological function (n=5; 0.40 – 0.56). Some limitations to potential enhancement, as catchment is located in Te Āpiti windfarm with planting restrictions. Potential values still much higher and representative of good to excellent potential ecological function (SEVi-P = 0.70 – 0.86) Macroinvertebrate indices indicative of localised habitat and water quality issues. Highest in hard bottom upper catchment with restricted stock access (MCI and MCI-sb= 64 to 88, QMCI = 2.19 to 4.32, % EPT abundance 0 to 8.64). Fish IBI 34, indicative of very poor, but healthy population of upland bully present in catchment.	Very High	Combined 3167 m stream impact across Catchment 4 (as per table below). 1899 m stream diversions being created across the catchment comprising 255 m Type 3, 1153 m Type 2 and 491 m Type 1. Of this, 985 m stream channel will be on top of spoil and has accordingly a lower ecological value. <table><tr><th>Catchment</th><th>Length (m)</th><th>Area (m2)</th></tr><tr><td>**4**</td><td>**3167**</td><td>**2583**</td></tr><tr><td>4A</td><td>991</td><td>1496</td></tr><tr><td>4B</td><td>541</td><td>370</td></tr><tr><td>4C</td><td>289</td><td>156</td></tr><tr><td>4D</td><td>650</td><td>262</td></tr><tr><td>4E</td><td>228</td><td>131</td></tr><tr><td>4F</td><td>467</td><td>168</td></tr></table>	Very High; will be offset to achieve no net loss in ecological function.

<table>
<tr><th>Catchment</th><th>Step 1: Ecological value</th><th>Reason for value including consideration of potential value</th><th>Step 2: Magnitude of effect</th><th>Reason for magnitude / overall effect following measures to offset effects, with relevant stream diversions and riparian planting detailed in Table H.17.</th><th>Step 4: Overall effect</th></tr>
<tr><td>Catchment 5</td><td>High</td><td>Steep, hard bottom stream systems in agricultural land use with fragmented riparian margins. Some existing sediment deposition, however cobbles and gravels provide habitat heterogeneity.
Macroinvertebrate indices highest of affected catchments, indicative of good and excellent water and habitat quality (up to MCI = 120). Moderate fish biotic integrity (48).
SEV scores indicative of good to excellent current ecological function (0.5 to 0.76). Potential enhancement limited by restrictions imposed by Te Āpiti windfarm, however still excellent potential ecological values if enhanced (SEVi-P = 0.75 to 0.83).</td><td></td><td>A combined 3311 m stream loss or impact proposed within Catchment 5 (as per table below).

1333 m Type 2 and 3 diversions being created within the catchment. 811 m will be located on top of spoil sites.

<table><tr><th>Catchment</th><th>Length (m)</th><th>Area (m2)</th></tr><tr><td>5</td><td>3311</td><td>1349</td></tr><tr><td>5A</td><td>785</td><td>355</td></tr><tr><td>5B</td><td>2526</td><td>994</td></tr></table></td><td></td></tr>
<tr><td>Catchment 6</td><td>High</td><td>Only kōura caught (IBI = 0). Assume same as Catchment 5 and longfin may be present. QEII protection over much of catchment. Riparian margins relatively intact, cobble bottom stream.
SEV conducted during NoRs was downstream of proposed impact area in much higher quality habitat. At this location, the SEVi-C score was 0.86, indicative of excellent quality. In the headwaters where the proposed impact will occur, the stream is highly modified and the SEVi-C score is a conservative assessment of potential value.</td><td>Very High</td><td>At the point of impact the stream bed is being lost and no diversions are being constructed.
The impact is restricted to a small section of Catchment 6, comprising only 127 m (39 m^2).</td><td>Very High; will be offset to achieve no net loss in ecological function.</td></tr>
</table>

<table>
<tr><th>Catchment</th><th>Step 1: Ecological value</th><th>Reason for value including consideration of potential value</th><th>Step 2: Magnitude of effect</th><th>Reason for magnitude / overall effect following measures to offset effects, with relevant stream diversions and riparian planting detailed in Table H.17.</th><th>Step 4: Overall effect</th></tr>
<tr><td>Catchment 7</td><td>High</td><td>Consists of three sub-catchments, two potentially affected by stormwater. Fish index of biotic integrity indicative of moderate value (54).
7A higher value, with intact riparian margins, fencing and good in-stream macroinvertebrate values. Some sections of stream exhibit depositional areas, however predominantly a steep catchment. SEV values indicative of good to high value stream systems (0.50, 0.78). Potential value following enhancement increases to 0.72 and 0.82. The existing vegetated QEII section is of existing good quality, so the potential for improvement is minimal.
Macroinvertebrate indices reflect good to excellent water quality and habitat values, including in pasture headwaters. Sensitive EPT taxa present in headwaters (up to 44% EPT abundance).
7B of lower current value in agricultural land, minimal margins and stock access unrestricted. Macroinvertebrate indices and reflective of poor water quality and degraded habitat. SEV scores moderate, 0.44 to 0.7. Potential for improvement good, with SEVi-P of between 0.85 and 0.86.</td><td>Very High</td><td>1195 m stream length impacted across 7A and 7B (as per table below). Majority is 7B which will be located under the Western Rise and will be replaced with a diversion along the western road embankment.
1544 m stream diversion being created, with 1491 m of this within catchment 7B. No diversions are proposed within catchment 7A.
<table>
<tr><th>Catchment</th><th>Length (m)</th><th>Area (m2)</th></tr>
<tr><td>7</td><td>1195</td><td>639</td></tr>
<tr><td>7A</td><td>395</td><td>123</td></tr>
<tr><td>7B</td><td>800</td><td>516</td></tr>
</table></td><td>Very High; will be offset to achieve no net loss in ecological function.</td></tr>
<tr><td>Catchment 8</td><td>Low</td><td>Highly modified, agricultural catchment. IBI indicative of poor biotic integrity (IBI = 24). Evidence of regular channel clearance for maintenance. SEV score indicative of poorly functioning ecosystem (0.31) and very</td><td>Very High</td><td>Within catchment 8, 1052 m stream is being impacted comprising 794 m^2 streambed area.</td><td>Moderate; will be offset to achieve no net loss in ecological function.</td></tr>
</table>

Catchment	Step 1: Ecological value	Reason for value including consideration of potential value	Step 2: Magnitude of effect	Reason for magnitude / overall effect following measures to offset effects, with relevant stream diversions and riparian planting detailed in Table H.17.	Step 4: Overall effect
		limited potential for enhancement given proximity to existing roading infrastructure and agricultural practices. (SEVi-P = 0.42).		990 m stream diversion being created comprising Type 1 and 3 diversions.	
Catchment 9	Moderate	While the wider catchment is high value based on shading and riparian vegetation within gully systems., the proposed impact location is very low ecological value. The reaches are unshaded, with unrestricted stock access and have been dammed to create farm ponds. Potential for enhancement is limited as stream systems fragmented from main reaches in catchment. SEV not undertaken in this location, however SEV values from 7B assigned, which are conservative given fragmentation of habitat.	Very High	A small area of 59 m stream length comprising 54 m^2 will be impacted on the upper western side of the western rise. No diversions are proposed within Catchment 9.	High; will be offset to achieve no net loss in ecological function.

CONCLUSION

302. In summary, the Project is anticipated to have effects on a range of freshwater ecology values. As far as practicable, effects on freshwater ecology have been avoided, minimised or mitigated.

303. The following measures are recommended to minimise and mitigate effects on aquatic ecology within the impact footprint and in the receiving environment.

   (a) Preparation of an Ecology Management Plan, and specific Freshwater Ecology Management Plan, to manage ecological effects during the construction and operation of the project including:

      (i) Fish Recovery Protocols to salvage and relocate fish from within works footprints;

      (ii) Vegetation Clearance Protocols to manage the potential effects of run off from cleared vegetation;

      (iii) Aquatic Ecology Monitoring to be implemented to provide baseline, during and following construction data;

      (iv) Details pertaining to stream diversion planting and ecological habitat requirements; and

      (v) Details pertaining to riparian planting to be undertaken at sites outside the designation in private ownership.

   (b) Fish passage to be provided during temporary in-stream works;

   (c) Culverts to be constructed to facilitate fish passage where practicable and in accordance with the recommendations;

   (d) Erosion and sediment controls to be implemented in accordance with Auckland Council GD05 and to be identified in a Construction and Environmental Management Plan;

   (e) Hazardous Substance Procedures (in the ESCP) to manage the potential effects of hazardous substances on the receiving environment;

   (f) Stormwater management approach to include a treatment train approach to Transport Agency standards; and

   (g) Construction methodologies to be consistent with GD05.

304. For those effects on stream habitat that cannot be avoided, remedied or mitigated, offsetting is to be provided following the ECR methodology and

comprising construction of Type 1, 2 and 3 stream diversions and riparian planting and fencing of intermittent and permanent streams. The final composition of the offset package will be determined following further discussions with landowners.

305. With those mitigation and offset measures in place, I conclude that the short- and long-term overall effects on freshwater ecology values from the construction and operation of the project will be as follows:

(a) Effects on freshwater fauna will be Low or Very Low;

(b) Sedimentation during construction will have Low to Moderate effects across most catchments and a Low level of effect following construction;

(c) Potential construction water quality effects will result in Low or Very Low effects;

(d) Effects on fish passage will range from Low to No effects;

(e) Long term changes relating to stormwater quality and quantity will be Low to Very Low; and

(f) Effects of stream habitat loss and modification will be Very High, but will be offset to achieve no net loss in ecological function.

306. Overall I consider the actual and potential effects of the Project on freshwater ecology can be adequately addressed through the measures described in this assessment.

Justine Quinn

APPENDIX H.1: ECOLOGICAL IMPACT ASSESSMENT GUIDELINES

Table H.19: Ecological values assigned to freshwater ecology

Value	Explanation	Characteristics
Very High	A reference quality watercourse in condition close to its pre-human condition with the expected assemblages of flora and fauna and no contributions of contaminants from human induced activities including agriculture. Negligible degradation e.g., stream within a native forest catchment.	Benthic invertebrate community typically has high diversity, species richness and abundance. Benthic invertebrate community contains many taxa that are sensitive to organic enrichment and settled sediments. Benthic community typically with no single dominant species or group of species. MCI scores typically 120 or greater. EPT richness and proportion of overall benthic invertebrate community typically high. SEV scores high, typically >0.8. Fish communities typically diverse and abundant. Riparian vegetation typically with a well-established closed canopy. Stream channel and morphology natural. Stream banks natural typically with limited erosion. Habitat natural and unmodified.
High	A watercourse with high ecological or conservation value but which has been modified through loss of riparian vegetation, fish barriers, and stock access or similar, to the extent it is no longer reference quality. Slight to moderate degradation e.g., exotic forest or mixed forest/agriculture catchment.	Benthic invertebrate community typically has high diversity, species richness and abundance. Benthic invertebrate community contains many taxa that are sensitive to organic enrichment and settled sediments. Benthic community typically with no single dominant species or group of species. MCI scores typically 80-100 or greater. EPT richness and proportion of overall benthic invertebrate community typically moderate to high. SEV scores moderate to high, typically 0.6-0.8. Fish communities typically diverse and abundant. Riparian vegetation typically with a well-established closed canopy. No pest or invasive fish (excluding trout and salmon) species present. Stream channel and morphology natural. Stream banks natural typically with limited erosion. Habitat largely unmodified.
Moderate	A watercourse which contains fragments of its former values but has a high proportion of tolerant fauna, obvious water quality issues and/or sedimentation issues. Moderate to high degradation e.g., high-	Benthic invertebrate community typically has low diversity, species richness and abundance. Benthic invertebrate community dominated by taxa that are not sensitive to organic enrichment and settled sediments. Benthic community typically with dominant species or group of species. MCI scores typically 40-80.

Value	Explanation	Characteristics
	intensity agriculture catchment.	EPT richness and proportion of overall benthic invertebrate community typically low. SEV scores moderate, typically 0.4-0.6. Fish communities typically moderate diversity of only 3-4 species. Pest or invasive fish species (excluding trout and salmon) may be present. Stream channel and morphology typically modified (e.g., channelised) Stream banks may be modified or managed and may be highly engineered and/or evidence of significant erosion. Riparian vegetation may have a well-established closed canopy. Habitat modified.
Low	A highly modified watercourse with poor diversity and abundance of aquatic fauna and significant water quality issues. Very high degradation e.g., modified urban stream	Benthic invertebrate community typically has low diversity, species richness and abundance. Benthic invertebrate community dominated by taxa that are not sensitive to organic enrichment and settled sediments. Benthic community typically with dominant species or group of species. MCI scores typically 60 or lower. EPT richness and proportion of overall benthic invertebrate community typically low or zero. SEV scores moderate to high, typically less than 0.4. Fish communities typically low diversity of only 1-2 species. Pest or invasive fish (excluding trout and salmon) species present. Stream channel and morphology typically modified (e.g., channelised). Stream banks often highly modified or managed and maybe highly engineered and/or evidence of significant erosion. Riparian vegetation typically without a well-established closed canopy. Habitat highly modified.

Table H.20: Criteria for describing magnitude of effect

Magnitude	Description
Very high	Total loss of, or very major alteration to, key elements/features/ of the existing baseline[1] conditions, such that the post-development character, composition and/or attributes will be fundamentally changed and may be lost from the site altogether; AND/OR Loss of a very high proportion of the known population or range of the element/feature
High	Major loss or major alteration to key elements/features of the existing baseline conditions such that the post-development character, composition and/or attributes will be fundamentally changed; AND/OR Loss of a high proportion of the known population or range of the element/feature
Moderate	Loss or alteration to one or more key elements/features of the existing baseline conditions, such that the post-development character, composition and/or attributes will be partially changed; AND/OR Loss of a moderate proportion of the known population or range of the element/feature
Low	Minor shift away from existing baseline conditions. Change arising from the loss/alteration will be discernible, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances or patterns; AND/OR Having a minor effect on the known population or range of the element/feature
Negligible	Very slight change from the existing baseline condition. Change barely distinguishable, approximating the 'no change' situation; AND/OR Having negligible effect on the known population or range of the element/feature

[1]Baseline conditions are defined as 'the conditions that would pertain in the absence of a proposed action' (Roper-Lindsay *et al*., 2018).

Table H.21: Timescale for duration of effects

Timescale	Description
Permanent	Effects continuing for an undefined time beyond the span of one human generation (taken as approximately 25 years)
Long-term	Where there is likely to be substantial improvement after a 25 year period (e.g. the replacement of mature trees by young trees that need > 25 years to reach maturity, or restoration of ground after removal of a development) the effect can be termed 'long term'
Temporary[1]	Long term (15-25 years or longer – see above) Medium term (5-15 years) Short term (up to 5 years) Construction phase (days or months)

[1]Note that in the context of some planning documents, 'temporary' can have a defined timeframe.

Table H.22: Criteria for describing overall levels of ecological effects.

Magnitude \ Ecological value	Very high	High	Moderate	Low	Negligible
Very high	Very high	Very high	High	Moderate	Low
High	Very high	Very high	Moderate	Low	Very low
Moderate	High	High	Moderate	Low	Very low
Low	Moderate	Low	Low	Very low	Very low
Negligible	Low	Very low	Very low	Very low	Very low
Positive	Net gain	Net gain	Net gain	Net gain	Net gain

Table H.19 adapted from Boffa Miskell Limited (various project reports).

Table H.20 to Table H.22 reproduced from Roper-Lindsay, J., Fuller, S.A., Hooson, S., Sanders, M.D., and Ussher, G.T. (2018). Ecological Impact Assessment. EIANZ guidelines for use in New Zealand: terrestrial and freshwater ecosystems. 2nd edition.

APPENDIX H.2: AUCKLAND UNITARY PLAN OPERATIVE IN PART - DEFINITIONS FOR WATERCOURSES AS APPLIED TO THE PROJECT.

Classification	AUP OP definition
River or stream	*A continually or intermittently flowing body of fresh water, excluding ephemeral streams, and includes a stream or modified watercourse; but does not include any artificial watercourse (including an irrigation canal, water supply race, canal for the supply of water for electricity power generation, and farm drainage canal except where it is a modified element of a natural drainage system).*
Permanent river or stream	*The continually flowing reaches of any river or stream.*
Intermittent stream	*Stream reaches that cease to flow for periods of the year because the bed is periodically above the water table. This category is defined by those stream reaches that do not meet the definition of permanent river or stream and meet at least three of the following criteria:* *it has natural pools;* *it has a well-defined channel, such that the bed and banks can be distinguished;* *it contains surface water more than 48 hours after a rain event which results in stream flow;* *rooted terrestrial vegetation is not established across the entire cross-sectional width of the channel;* *organic debris resulting from flood can be seen on the floodplain; or* *there is evidence of substrate sorting process, including scour and deposition.*
Ephemeral stream	*Stream reaches with a bed above the water table at all times, with water only flowing during and shortly after rain events. This category is defined as those stream reaches that do not meet the definition of permanent river or stream or intermittent stream.*
Artificial watercourse	*Constructed watercourses that contain no natural portions from their confluence with a river or stream to their head waters.* *Includes:* *canals that supply water to electricity power generation plants;* *farm drainage canals;* *irrigation canals; and* *water supply races.* *Excludes:* *naturally occurring watercourses.*

APPENDIX H.3: ASSUMPTIONS ASSOCIATED WITH SEV CALCULATIONS

Impact SEV scores

Modelled SEVi-P scores were calculated for each SEV site to inform ECR calculations (Table H.23).
There was no modelled change for variables Vpipe, Vbarr, Vdepth,Vripconn, Vgalspawn, Vimperv, Vveloc. Consistent with the method, Vfish, Vmci, Vinvert, Vept were excluded from modelled assumptions. Variables Vchanshape, Vretain, Vgobspawn and Vripcond are autopopulated.

Table H.23: Summary assumptions assigned to modelled SEVi-P scores for use in ECR.

SEV ID	Within or outside of Te Āpiti wind farm	Location in catchment	Overarching restoration proposed.
SEV1A	Not wind farm	Mid-catchment	Riparian margins fenced and planted to 20 m on each bank.
SEV2B1	Not wind farm	Mid-catchment	Riparian margins fenced and planted to 20 m on each bank
SEV2C	Not wind farm	Small catchment	Riparian margins fenced and planted to 20 m on each bank
SEV2C2	Not wind farm	Mid-catchment	Riparian margins fenced and planted to 20 m on each bank
SEV2C8	Not wind farm	Small catchment	Riparian margins fenced and planted to 20 m on each bank
SEV2E	Not wind farm	Mid-catchment	Riparian margins fenced and planted to 20 m on each bank
SEV2E2	Not wind farm	Small catchment	Riparian margins fenced and planted to 20 m on each bank
SEV3A	Not wind farm	Mid-catchment	Riparian margins fenced and planted to 20 m on each bank
SEV3B	Not wind farm	Small catchment	Riparian margins fenced and planted to 20 m on each bank
SEV4A	Te Āpiti Wind Farm	Mid-catchment	Riparian margins fenced and planted to 20 m on each bank (vegetation <1.5 m tall*)
SEV4A 3 + 4	Te Āpiti Wind Farm	Mid-catchment	Riparian margins fenced and planted to 20 m on each bank (vegetation <1.5 m tall*)
SEV4B	Te Āpiti Wind Farm	Small catchment	Riparian margins fenced and planted to 20 m on each bank (vegetation <1.5 m tall*)
SEV4C1	Te Āpiti Wind Farm	Small catchment	Riparian margins fenced and planted to 20 m on each bank (vegetation <1.5 m tall*)
SEV4F	Te Āpiti Wind Farm	Small catchment	Riparian margins fenced and planted to 20 m on each bank (vegetation <1.5 m tall*)
SEV5Ab d/s	Te Āpiti Wind Farm	Mid-catchment	Riparian margins fenced and planted to 20 m on each bank (vegetation <1.5 m tall*)
SEV5Aa u/s	Te Āpiti Wind Farm	Mid-catchment	Riparian margins fenced and planted to 20 m on each bank (vegetation <1.5 m tall*)
SEV5A9	Te Āpiti Wind Farm	Mid-catchment	Riparian margins fenced and planted to 20 m on each bank (vegetation <1.5 m tall*)
SEV5B6	Te Āpiti Wind Farm	Mid-catchment	Riparian margins fenced and planted to 20 m on each bank (vegetation <1.5 m tall*)
SEV5B7	Te Āpiti Wind Farm	Small catchment	Riparian margins fenced and planted to 20 m on each bank (vegetation <1.5 m tall*)
SEV5B9	Te Āpiti Wind Farm	Small catchment	Riparian margins fenced and planted to 20 m on each bank (vegetation <1.5 m tall*)
SEV7A1	Te Āpiti Wind Farm	Small catchment	Riparian margins fenced and planted to 20 m on each bank (vegetation <1.5 m tall*)
SEV7A2	Te Āpiti Wind Farm	Small catchment	Riparian margins fenced and planted to 20 m on each bank (vegetation <1.5 m tall*)
SEV7B	Not wind farm	Mid-catchment	Riparian margins fenced and planted to 20 m on each bank
SEV7B 1 +2	Not wind farm	Small catchment	Riparian margins fenced and planted to 20 m on each bank
SEV7B0	Not wind farm	Mid-catchment	Riparian margins fenced and planted to 20 m on each bank
SEV8A1	Not wind farm	Mid-catchment	Riparian margins fenced and planted to 20 m on one bank. Road within other bank.

Notes: * as per default approach to Wind Farm planting in proposed designation conditions

Offset SEV scores

Ratahiwi Farm

SEVm-C values measured and representative SEVs assigned to similar stream reaches within the Ratahiwi Farm site. Modelled SEVm-P scores based on whole of catchment, gully scale restoration with 20 m riparian margins and stock exclusion fencing. The final configuration of stream enhancement to be undertaken as part of the offset package will be developed following further consultation with the landowners.

Offset Location SEV name	Type	Length potentially available (m)	Area potentially available (m^2)	SEVm-C	SEVm-P
SEV1	Permanent	5076	4280	0.57	0.94
SEV2	Permanent	2647	2707	0.62	0.89
SEV3	Intermittent	6407	1297	0.42	0.88
SEV4	Intermittent	6569	1018	0.61	0.86
SEV5	Intermittent	2735	1143	0.44	0.88

APPENDIX H.4: SUMMARY REACH BASED ECR CALCULATIONS

Impact data						Culvert effects							Infill effects			Summary offset data	
FullReachID	sloped_length	AverageWidth(m)	Total impact area (m2)	RepresentativeSEV	SEVi-P	Culvert name	Culvert length (m)	Culvert SEVi-I	Offset Location	Culvert ECR	(Culvert) Offset area required (m2)	Residual effects area (m2)	Offset Location	Infill ECR	(Infill) Offset area required (m2)	Total area to achieve no net loss	Average ratio (ECR)
1A1	240.4	0.5	128.2	SEV1A	0.68		N/A	N/A		N/A	N/A	128.2	SD-MC18-02	1.65	210.9	210.9	1.65
1A2	134.2	0.5	71.6	SEV1A	0.68		N/A	N/A		N/A	N/A	71.6	SD-MC18-01	1.65	117.8	117.8	1.65
1B1	234.6	1.9	445.6	SEV1A	0.68	CU-18A	44	0.23	SD-MC18B-01	1.20	100.0	362.0	SEV3	2.23	806.0	906.1	2.03
1B2	118.0	1.9	224.1	SEV1A	0.68	CU-17B	47.77	0.23	SD-MC18-03	1.09	98.8	133.3	SEV3	2.23	296.9	395.7	1.77
2B1	62.5	1.7	104.2	SEV2B1	0.54		N/A	N/A		N/A	N/A	104.2	SD-MC17A-02	1.31	136.9	136.9	1.31
2C	391.7	0.7	287.2	SEV2C	0.90	CU-17	135.12	0.15	SEV4	4.41	437.1	188.1	SD-MC17-01	2.36	444.0	881.1	3.07
2C1	35.8	0.1	2.4	SEV2C	0.90		N/A	N/A		N/A	N/A	2.4	SD-MC17-05	2.36	5.6	5.6	2.36
2C10	28.2	0.1	1.4	SEV2C8	0.91		N/A	N/A		N/A	N/A	1.4	SD-MC17-05	2.39	3.4	3.4	2.39
2C11	21.4	0.2	3.9	SEV2C	0.90		N/A	N/A		N/A	N/A	3.9	SD-MC17-05	2.36	9.3	9.3	2.36
2C12	94.4	0.6	55.1	SEV2C2	0.79		N/A	N/A		N/A	N/A	55.1	SD-MC17-05	2.08	114.3	114.3	2.08
2C13	11.2	0.6	6.5	SEV2C2	0.79		N/A	N/A		N/A	N/A	6.5	SD-MC17-05	2.08	13.6	13.6	2.08
2C3	19.9	0.4	7.3	SEV2C	0.90		N/A	N/A		N/A	N/A	7.3	SD-MC17-05	2.36	17.2	17.2	2.36
2C4	14.2	0.2	2.1	SEV2C	0.90		N/A	N/A		N/A	N/A	2.1	SD-MC17-05	2.36	5.0	5.0	2.36
2C5	138.7	0.0	0.0	SEV2C	0.90		N/A	N/A		N/A	N/A	0.0	Not Required	N/A	N/A	N/A	N/A
2C6	31.0	0.3	8.8	SEV2C	0.90		N/A	N/A		N/A	N/A	8.8	SD-MC17-05	2.36	20.8	20.8	2.36
2C7	25.3	0.2	4.2	SEV2C	0.90		N/A	N/A		N/A	N/A	4.2	SD-MC17-05	2.36	9.9	9.9	2.36
2C8	165.1	0.2	30.3	SEV2C8	0.91		N/A	N/A		N/A	N/A	30.3	SD-MC17-05	2.39	72.3	72.3	2.39
2C9	20.8	0.1	1.7	SEV2C8	0.91		N/A	N/A		N/A	N/A	1.7	SD-MC17-05	2.39	4.1	4.1	2.39
2E	330.9	0.2	55.1	SEV2E	0.87		N/A	N/A		N/A	N/A	55.1	SD-DS20-01	2.58	142.0	142.0	2.58
2E1	27.6	0.1	1.8	SEV2E	0.87		N/A	N/A		N/A	N/A	1.8	SD-DS20-01	2.58	4.7	4.7	2.58
2E10	29.9	0.7	20.9	SEV2E	0.87		N/A	N/A		N/A	N/A	20.9	SD-DS20-01	2.58	53.9	53.9	2.58
2E11	35.4	0.7	24.8	SEV2E	0.87		N/A	N/A		N/A	N/A	24.8	SD-DS20-01	2.58	63.9	63.9	2.58
2E12a	17.6	0.4	6.4	SEV2E	0.87		N/A	N/A		N/A	N/A	6.4	SD-DS20-01	2.58	16.6	16.6	2.58

Impact data						Culvert effects							Infill effects			Summary offset data	
FullReachID	sloped_length	AverageWidth(m)	Total impact area (m2)	RepresentativeSEV	SEVi-P	Culvert name	Culvert length (m)	Culvert SEVi-I	Offset Location	Culvert ECR	(Culvert) Offset area required (m2)	Residual effects area (m2)	Offset Location	Infill ECR	(Infill) Offset area required (m2)	Total area to achieve no net loss	Average ratio (ECR)
2E12b	51.4	0.4	18.8	SEV2E	0.87		N/A	N/A		N/A	N/A	18.8	SD-DS20-01	2.58	48.5	48.5	2.58
2E13	130.3	0.8	104.3	SEV2E	0.87		N/A	N/A		N/A	N/A	104.3	SEV1	3.58	373.0	373.0	3.58
2E16	69.7	0.2	11.6	SEV2E	0.87		N/A	N/A		N/A	N/A	11.6	SD-DS20-01	2.58	29.9	29.9	2.58
2E17	13.1	0.1	1.7	SEV2E	0.87		N/A	N/A		N/A	N/A	1.7	SD-DS20-01	2.58	4.5	4.5	2.58
2E18	55.1	0.2	12.9	SEV2E	0.87		N/A	N/A		N/A	N/A	12.9	SD-DS20-01	2.58	33.1	33.1	2.58
2E19	118.2	0.7	82.7	SEV2E	0.87		N/A	N/A		N/A	N/A	82.7	SEV1	3.58	296.0	296.0	3.58
2E2	176.5	0.3	52.9	SEV2E2	0.87		N/A	N/A		N/A	N/A	52.9	SEV1	3.58	189.4	189.4	3.58
2E3	8.8	1.2	10.2	SEV2E2	0.87		N/A	N/A		N/A	N/A	10.2	SD-DS20-01	2.58	26.4	26.4	2.58
2E4	48.2	0.3	16.1	SEV2E2	0.87		N/A	N/A		N/A	N/A	16.1	SD-DS20-01	2.58	41.4	41.4	2.58
2E5	45.5	0.4	16.7	SEV2E2	0.87		N/A	N/A		N/A	N/A	16.7	SD-DS20-01	2.58	42.9	42.9	2.58
2E6a	23.7	0.8	18.2	SEV2E2	0.87		N/A	N/A		N/A	N/A	18.2	SEV1	3.58	65.1	65.1	3.58
2E6b	15.6	0.8	12.0	SEV2E	0.87		N/A	N/A		N/A	N/A	12.0	SEV1	3.58	42.9	42.9	3.58
2E7	50.6	1.0	50.6	SEV2E2	0.87		N/A	N/A		N/A	N/A	50.6	SEV1	3.58	181.0	181.0	3.58
2E8	39.2	0.4	14.4	SEV2E	0.87		N/A	N/A		N/A	N/A	14.4	SEV1	3.58	51.4	51.4	3.58
2E9	60.3	0.8	45.2	SEV2E	0.87		N/A	N/A		N/A	N/A	45.2	SEV1	3.58	161.8	161.8	3.58
3A	172.9	0.3	54.8	SEV3A	0.73	CU-15	172.8972	0.23	SEV1	2.03	111.4	0.0	Not Required	N/A	N/A	N/A	N/A
3A10	17.9	0.1	1.5	SEV3B	0.91	CU-14	17.88252	0.15	SEV4	4.48	6.7	0.0	Not Required	N/A	N/A	N/A	N/A
3A11	10.6	0.2	2.3	SEV3A	0.73	CU-14	10.60852	0.15	SEV4	3.40	7.8	0.0	Not Required	N/A	N/A	N/A	N/A
3A3	21.6	1.0	20.9	SEV3A	0.73	CU-14	21.62597	0.15	SEV1	2.36	49.4	0.0	Not Required	N/A	N/A	N/A	N/A
3A5	16.3	0.0	0.7	SEV3A	0.73	ACU-08	0	0.15	SEV4	3.40	0.0	0.7	Not Required	N/A	N/A	N/A	N/A
3A8a	27.7	0.2	6.0	SEV3A	0.73	CU-14	27.66104	0.15	SEV4	3.40	20.4	0.0	Not Required	N/A	N/A	N/A	N/A
3A8b	35.7	0.2	7.7	SEV3A	0.73	ACU-07	32.57	0.23	SEV4	2.93	20.6	0.7	Not Required	N/A	N/A	N/A	N/A
3B	67.2	0.3	17.9	SEV3B	0.91		N/A	N/A		N/A	N/A	17.9	SD-MC16-04	2.48	44.5	44.5	2.48
3B1	29.4	0.2	4.9	SEV3B	0.91		N/A	N/A		N/A	N/A	4.9	SEV4	5.36	26.3	26.3	5.36
3B2	135.6	0.2	31.6	SEV3B	0.91	CU-16	0	0.15	SEV5	2.62	0.0	31.6	SEV3	2.98	94.2	94.2	2.98

Impact data						Culvert effects							Infill effects			Summary offset data	
FullReachID	sloped_length	AverageWidth(m)	Total impact area (m2)	RepresentativeSEV	SEVi-P	Culvert name	Culvert length (m)	Culvert SEVi-I	Offset Location	Culvert ECR	(Culvert) Offset area required (m2)	Residual effects area (m2)	Offset Location	Infill ECR	(Infill) Offset area required (m2)	Total area to achieve no net loss	Average ratio (ECR)
3B3a	33.5	0.2	5.6	SEV3A	0.73		N/A	N/A		N/A	N/A	5.6	SD-MC16-04	1.98	11.1	11.1	1.98
3B3b	32.3	0.2	5.4	SEV3A	0.73		N/A	N/A		N/A	N/A	5.4	SD-MC16-04	1.98	10.7	10.7	1.98
3B5	8.8	0.1	0.9	SEV3A	0.73		N/A	N/A		N/A	N/A	0.9	Not Required	N/A	N/A	N/A	N/A
3B6	11.5	0.1	1.5	SEV3B	0.91		N/A	N/A		N/A	N/A	1.5	SD-MC16-04	2.48	3.8	3.8	2.48
3B8	21.8	0.1	1.8	SEV3A	0.73		N/A	N/A		N/A	N/A	1.8	SD-MC16-04	1.98	3.6	3.6	1.98
3B9	10.1	0.1	1.3	SEV3A	0.73		N/A	N/A		N/A	N/A	1.3	SD-MC16-04	1.98	2.7	2.7	1.98
4A	356.6	1.5	534.8	SEV4A	0.79		N/A	N/A		N/A	N/A	534.8	SD-MC10-04	2.34	1251.1	1251.1	2.34
4A1	41.6	0.2	8.7	SEV4D	0.86		N/A	N/A		N/A	N/A	8.7	SD-MC11-03	2.36	20.6	20.6	2.36
4A2b	96.1	0.3	28.8	SEV4D	0.86	CU-11	62.16	0.23	SEV5	2.18	40.7	10.2	SEV4	5.09	51.8	92.6	3.21
4A3	116.3	2.2	251.9	SEV4A 3 + 4	0.70	CU-08	86.83	0.23	SEV1	1.95	366.2	63.8	SD-AC05-02	1.77	113.1	479.3	1.90
4A4	108.3	2.7	296.0	SEV4A 3 + 4	0.70	ACU-05	42.34	0.23	SEV1	1.95	225.3	180.2	SD-MC10-03	1.94	349.9	575.2	1.94
4B1	80.3	0.4	33.5	SEV4A 3 + 4	0.70		N/A	N/A		N/A	N/A	33.5	SD-AC05A-01	1.77	59.3	59.3	1.77
4B15	189.2	1.2	220.7	SEV4F	0.77		N/A	N/A		N/A	N/A	220.7	SD-AC05A-01	1.94	428.0	428.0	1.94
4B15a	21.9	0.0	0.0	SEV4F	0.77		N/A	N/A		N/A	N/A	0.0	Not Required	N/A	N/A	N/A	N/A
4B2	26.5	0.5	13.2	SEV4A 3 + 4	0.70		N/A	N/A		N/A	N/A	13.2	SD-AC05-01	1.77	23.5	23.5	1.77
4B3	113.0	0.5	56.5	SEV2B1	0.54		N/A	N/A		N/A	N/A	56.5	SD-AC05-01	1.37	77.2	77.2	1.37
4C1	111.6	0.5	50.2	SEV4C1	0.80	CU-09	111.25	0.23	SEV5	1.98	98.9	0.1	Not Required	N/A	N/A	N/A	N/A
4C2	79.2	0.7	51.5	SEV4F	0.77	CU-08A	76.70546	0.23	SEV5	1.86	92.9	1.6	SD-MC09-03	2.12	3.4	96.3	1.87
4D	252.6	0.5	117.9	SEV4D	0.86	CU-10	103.16	0.23	SEV1	2.60	125.2	69.7	SEV2	4.72	329.0	454.2	3.85
4D1	5.4	0.1	0.4	SEV4D	0.86		N/A	N/A		N/A	N/A	0.4	Not Required	N/A	N/A	N/A	N/A
4D2	36.3	0.2	5.4	SEV4D	0.86		N/A	N/A		N/A	N/A	5.4	SEV3	2.83	15.4	15.4	2.83
4D3	24.0	0.2	3.6	SEV4D	0.86		N/A	N/A		N/A	N/A	3.6	SEV3	2.83	10.2	10.2	2.83
4D4	71.6	0.2	13.1	SEV4D	0.86		N/A	N/A		N/A	N/A	13.1	SEV3	2.83	37.1	37.1	2.83
4D5	233.8	0.5	109.1	SEV4D	0.86		N/A	N/A		N/A	N/A	109.1	SEV5	2.98	324.8	324.8	2.98
4D5a	26.0	0.5	12.1	SEV4D	0.86		N/A	N/A		N/A	N/A	12.1	SEV3	2.83	34.3	34.3	2.83

Impact data						Culvert effects							Infill effects			Summary offset data	
FullReachID	sloped_length	AverageWidth(m)	Total impact area (m2)	RepresentativeSEV	SEVi-P	Culvert name	Culvert length (m)	Culvert SEVi-I	Offset Location	Culvert ECR	(Culvert) Offset area required (m2)	Residual effects area (m2)	Offset Location	Infill ECR	(Infill) Offset area required (m2)	Total area to achieve no net loss	Average ratio (ECR)
4E	113.1	0.4	49.0	SEV4F	0.77		N/A	N/A		N/A	N/A	49.0	SEV4	4.54	222.8	222.8	4.54
4E1	59.9	0.8	48.0	SEV4F	0.77	CU-12	35.48512	0.23	SEV5	1.86	52.9	19.6	SEV4	4.54	88.9	141.8	2.96
4F	188.3	0.4	72.2	SEV4F	0.77	CU-13	78.87	0.15	SEV5	2.14	64.7	42.0	SD-AC05-01	1.94	81.3	146.0	2.02
4F1	28.6	0.0	0.0	SEV7A2	0.72		N/A	N/A		N/A	N/A	0.0	Not Required	N/A	N/A	N/A	N/A
4F2	77.5	0.9	68.5	SEV7A2	0.72		N/A	N/A		N/A	N/A	68.5	SD-MC13-02	2.34	160.2	160.2	2.34
4F3	105.6	0.2	17.6	SEV4F	0.77		N/A	N/A		N/A	N/A	17.6	SEV4	4.54	80.0	80.0	4.54
4F4	57.0	0.1	6.7	SEV4F	0.77		N/A	N/A		N/A	N/A	6.7	SD-AC06-02	2.12	14.1	14.1	2.12
5A1	1.0	0.3	0.3	SEV5Aa u/s	0.79		N/A	N/A		N/A	N/A	0.3	Not Required	N/A	N/A	N/A	N/A
5A10	54.4	0.1	5.4	SEV5Aa u/s	0.79		N/A	N/A		N/A	N/A	5.4	SD-MC05-01	2.35	12.8	12.8	2.35
5A11	19.6	0.1	1.6	SEV5Ab d/s	0.81		N/A	N/A		N/A	N/A	1.6	SD-MC05-01	2.40	3.9	3.9	2.40
5A12	25.3	0.1	2.1	SEV5Aa u/s	0.79		N/A	N/A		N/A	N/A	2.1	SD-MC05-01	2.35	4.9	4.9	2.35
5A2	35.8	0.1	3.6	SEV5Ab d/s	0.81		N/A	N/A		N/A	N/A	3.6	SD-MC05-01	2.40	8.6	8.6	2.40
5A3	36.5	0.0	1.2	SEV5Aa u/s	0.79		N/A	N/A		N/A	N/A	1.2	SD-MC07-05	2.19	2.7	2.7	2.19
5A4	41.8	0.1	3.5	SEV5Aa u/s	0.79		N/A	N/A		N/A	N/A	3.5	SD-MC05-01	2.35	8.2	8.2	2.35
5A5	27.0	0.1	2.4	SEV5Aa u/s	0.79		N/A	N/A		N/A	N/A	2.4	SD-MC07-05	2.19	5.3	5.3	2.19
5A6	88.5	0.1	8.8	SEV5Aa u/s	0.79	CU-07	88.46609	0.15	SEV4	3.80	33.6	0.0	Not Required	N/A	N/A	N/A	N/A
5A7	66.7	0.2	10.0	SEV5Aa u/s	0.79		N/A	N/A		N/A	N/A	10.0	SD-MC07-05	2.19	21.9	21.9	2.19
5A8	26.6	0.1	2.1	SEV5Aa u/s	0.79		N/A	N/A		N/A	N/A	2.1	SD-MC03-08	2.16	4.6	4.6	2.16
5A9	64.8	0.4	25.9	SEV5A9	0.83		N/A	N/A		N/A	N/A	25.9	SD-MC07-02	2.28	59.0	59.0	2.28
5Aa	106.6	1.2	124.3	SEV5Aa u/s	0.79		N/A	N/A		N/A	N/A	124.3	SEV2	4.34	539.4	539.4	4.34
5Ab	117.9	1.2	137.5	SEV5Ab d/s	0.81	CU-07	97.38391	0.15	SEV1	2.72	308.6	23.9	SD-AC03-02	2.24	53.5	362.1	2.63
5B	52.0	0.8	41.6	SEV5B6	0.75		N/A	N/A		N/A	N/A	41.6	SEV2	4.09	170.4	170.4	4.09
5B10	42.1	0.1	2.9	SEV5B9	0.82		N/A	N/A		N/A	N/A	2.9	SD-MC05-03	2.66	7.8	7.8	2.66
5B11	36.3	0.1	3.0	SEV5B9	0.82		N/A	N/A		N/A	N/A	3.0	SD-MC05-03	2.66	8.0	8.0	2.66
5B12	52.9	0.5	28.2	SEV5B9	0.82		N/A	N/A		N/A	N/A	28.2	SD-MC05-03	2.66	74.9	74.9	2.66

Impact data						Culvert effects							Infill effects			Summary offset data	
FullReachID	sloped_length	AverageWidth(m)	Total impact area (m2)	RepresentativeSEV	SEVi-P	Culvert name	Culvert length (m)	Culvert SEVi-I	Offset Location	Culvert ECR	(Culvert) Offset area required (m2)	Residual effects area (m2)	Offset Location	Infill ECR	(Infill) Offset area required (m2)	Total area to achieve no net loss	Average ratio (ECR)
5B13	5.8	0.2	1.2	SEV5B9	0.82		N/A	N/A		N/A	N/A	1.2	SD-MC05-03	2.66	3.1	3.1	2.66
5B14	57.9	0.4	20.3	SEV5B9	0.82		N/A	N/A		N/A	N/A	20.3	SD-MC05-03	2.66	53.9	53.9	2.66
5B15	46.0	0.2	8.4	SEV5B9	0.82		N/A	N/A		N/A	N/A	8.4	SD-MC05-03	2.66	22.4	22.4	2.66
5B16	30.6	0.2	6.1	SEV5B9	0.82		N/A	N/A		N/A	N/A	6.1	SD-MC07-05	2.26	13.8	13.8	2.26
5B17	51.9	0.4	19.0	SEV5B7	0.77		N/A	N/A		N/A	N/A	19.0	SD-MC05-03	2.50	47.5	47.5	2.50
5B18	32.2	0.0	1.2	SEV5B7	0.77		N/A	N/A		N/A	N/A	1.2	SD-AC03-02	2.12	2.5	2.5	2.12
5B19	32.0	0.1	4.3	SEV5B7	0.77		N/A	N/A		N/A	N/A	4.3	SD-AC03-02	2.12	9.0	9.0	2.12
5B2	85.1	0.2	19.9	SEV5B7	0.77		N/A	N/A		N/A	N/A	19.9	SD-MC03-08	2.10	41.7	41.7	2.10
5B20	116.9	0.4	46.8	SEV5B7	0.77		N/A	N/A		N/A	N/A	46.8	SD-MC05-03	2.50	116.7	116.7	2.50
5B21	19.7	0.5	9.8	SEV5B7	0.77		N/A	N/A		N/A	N/A	9.8	SD-AC03-02	2.12	20.9	20.9	2.12
5B22	55.3	0.3	17.9	SEV5B7	0.77		N/A	N/A		N/A	N/A	17.9	SD-AC03-02	2.12	37.9	37.9	2.12
5B23	247.0	0.3	65.9	SEV5B7	0.77	CU-06	0	0.15	SEV5	2.14	0.0	65.9	SD-AC03-02	2.12	139.7	139.7	2.12
5B24	12.5	0.1	1.0	SEV5B7	0.77		N/A	N/A		N/A	N/A	1.0	SD-MC03-08	2.10	2.1	2.1	2.10
5B25	50.1	0.2	7.5	SEV5B7	0.77		N/A	N/A		N/A	N/A	7.5	SD-MC03-08	2.10	15.8	15.8	2.10
5B26	23.2	0.1	1.2	SEV5B7	0.77		N/A	N/A		N/A	N/A	1.2	SD-MC03-08	2.10	2.4	2.4	2.10
5B27	30.1	0.7	22.1	SEV5B7	0.77		N/A	N/A		N/A	N/A	22.1	SD-MC03-08	2.10	46.3	46.3	2.10
5B3	11.3	0.1	1.1	SEV5B7	0.77		N/A	N/A		N/A	N/A	1.1	SD-MC03-08	2.10	2.4	2.4	2.10
5B4	23.5	0.1	1.3	SEV5B7	0.77		N/A	N/A		N/A	N/A	1.3	SD-MC03-08	2.10	2.8	2.8	2.10
5B5	17.5	0.1	2.0	SEV5B7	0.77		N/A	N/A		N/A	N/A	2.0	SD-MC03-08	2.10	4.3	4.3	2.10
5B6	294.4	0.6	176.6	SEV5B6	0.75	CU-04	90.46	0.23	SEV1	2.13	115.7	122.4	SEV2	4.09	501.1	616.8	3.49
5B7	309.6	0.2	72.2	SEV5B7	0.77		N/A	N/A		N/A	N/A	72.2	SD-AC03-02	2.12	153.2	153.2	2.12
5B7a	29.6	0.0	0.0	SEV5B7	0.77		N/A	N/A		N/A	N/A	0.0	Not Required	N/A	N/A	N/A	N/A
5B8	20.9	0.0	0.4	SEV5B7	0.77		N/A	N/A		N/A	N/A	0.4	Not Required	N/A	N/A	N/A	N/A
5B9	445.5	0.7	289.6	SEV5B9	0.82	CU-05	97.38	0.15	SEV5	2.31	146.1	226.3	SD-MC05-01	2.42	547.8	693.9	2.40
5B9a	8.3	0.3	2.8	SEV5B9	0.82		N/A	N/A		N/A	N/A	2.8	SD-MC03-08	2.23	6.2	6.2	2.23

Impact data						Culvert effects							Infill effects			Summary offset data	
FullReachID	sloped_length	AverageWidth(m)	Total impact area (m2)	RepresentativeSEV	SEVi-P	Culvert name	Culvert length (m)	Culvert SEVi-I	Offset Location	Culvert ECR	(Culvert) Offset area required (m2)	Residual effects area (m2)	Offset Location	Infill ECR	(Infill) Offset area required (m2)	Total area to achieve no net loss	Average ratio (ECR)
6A1	58.1	0.1	7.7	NoR6A	0.86		N/A	N/A		N/A	N/A	7.7	SEV1	3.53	27.3	27.3	3.53
6A2	68.9	0.5	31.0	NoR6A	0.86		N/A	N/A		N/A	N/A	31.0	SEV5	2.96	91.9	91.9	2.96
7A1	93.0	0.6	55.8	SEV7A1	0.82		N/A	N/A		N/A	N/A	55.8	SD-MC03-09	2.37	132.0	132.0	2.37
7A1a	13.5	1.4	18.4	SEV7B0	0.86		N/A	N/A		N/A	N/A	18.4	SD-MC03-05	2.53	46.5	46.5	2.53
7A2	45.6	0.3	12.9	SEV7A2	0.72		N/A	N/A		N/A	N/A	12.9	SD-MC03-09	2.08	26.9	26.9	2.08
7A3	123.4	0.1	12.3	SEV7A2	0.72		N/A	N/A		N/A	N/A	12.3	SD-MC03-08	1.97	24.3	24.3	1.97
7A3a	23.5	0.0	0.0	SEV7A2	0.72		N/A	N/A		N/A	N/A	0.0	Not Required	N/A	N/A	N/A	N/A
7A4	48.7	0.2	11.4	SEV7A2	0.72		N/A	N/A		N/A	N/A	11.4	SD-MC03-09	2.08	23.6	23.6	2.08
7A5	21.3	0.2	4.8	SEV7A2	0.72		N/A	N/A		N/A	N/A	4.8	SD-MC03-09	2.08	10.0	10.0	2.08
7A6	25.7	0.3	7.7	SEV7A2	0.72		N/A	N/A		N/A	N/A	7.7	SD-MC03-09	2.08	16.0	16.0	2.08
7B	160.0	0.8	125.3	SEV7B0	0.86	CU-03	75.71	0.15	SEV1	2.89	171.6	66.0	SD-MC03-05	2.53	166.7	338.3	2.70
7B	0.0	0.8		SEV7B0	0.86		N/A	N/A		N/A	N/A	0.0	Not Required	N/A	N/A	N/A	N/A
7B1	82.9	0.5	44.2	SEV7B 1 +2	0.86		N/A	N/A		N/A	N/A	44.2	SD-MC03-05	2.54	112.3	112.3	2.54
7B2	86.9	0.6	55.0	SEV7B 1 +2	0.86		N/A	N/A		N/A	N/A	55.0	SD-MC03-08	2.34	129.0	129.0	2.34
7B4	56.0	0.4	24.3	SEV7B 1 +2	0.86		N/A	N/A		N/A	N/A	24.3	SD-MC03-08	2.34	56.9	56.9	2.34
7B5	172.7	0.5	77.7	SEV7B	0.85		N/A	N/A		N/A	N/A	77.7	SD-MC03-01	2.46	190.9	190.9	2.46
7Be	241.5	0.8	189.2	SEV7B	0.85		N/A	N/A		N/A	N/A	189.2	SD-MC03-05	2.51	475.7	475.7	2.51
8A1	420.4	0.9	378.4	SEV8A1	0.42	CU-01	0	0.15	SEV5	0.93	0.0	378.4	SD-AC01-04	1.01	383.1	383.1	1.01
8A2	133.3	0.6	77.8	SEV5B7	0.77	CU-02	0	0.15	SEV5	2.14	0.0	77.8	SD-AC01-04	1.86	144.8	144.8	1.86
8A3	127.8	0.5	63.9	SEV7B	0.85		N/A	N/A		N/A	N/A	63.9	SD-AC01-04	2.06	131.7	131.7	2.06
8A4	12.4	0.6	7.2	SEV7B	0.85		N/A	N/A		N/A	N/A	7.2	SD-AC01-04	2.06	14.9	14.9	2.06
8A5	184.7	0.8	153.9	SEV7B	0.85		N/A	N/A		N/A	N/A	153.9	SD-AC01-04	2.06	317.0	317.0	2.06
8A6	92.6	0.4	40.1	SEV7B	0.85		N/A	N/A		N/A	N/A	40.1	SD-AC01-04	2.06	82.7	82.7	2.06
9A1	29.5	1.2	35.5	SEV7B 1 +2	0.86		N/A	N/A		N/A	N/A	35.5	SEV5	2.96	105.0	105.0	2.96
9A2	19.1	0.5	10.1	SEV7B 1 +2	0.86		N/A	N/A		N/A	N/A	10.1	SEV5	2.96	30.1	30.1	2.96

Impact data						Culvert effects							Infill effects			Summary offset data	
FullReachID	sloped_length	AverageWidth(m)	Total impact area (m2)	RepresentativeSEV	SEVi-P	Culvert name	Culvert length (m)	Culvert SEVi-I	Offset Location	Culvert ECR	(Culvert) Offset area required (m2)	Residual effects area (m2)	Offset Location	Infill ECR	(Infill) Offset area required (m2)	Total area to achieve no net loss	Average ratio (ECR)
NZT5B2	99.3	0.7	69.5	SEV5B6	0.75	ACU-03	98.49	0.23	SEV1	2.13	147.0	0.6	Not Required	N/A	N/A	N/A	N/A
NZTA1A4	45.9	0.5	24.5	SEV1A	0.68		N/A	N/A		N/A	N/A	24.5	SD-MC20-02	1.65	40.3	40.3	1.65
NZTA1A5	93.3	0.5	49.7	SEV1A	0.68		N/A	N/A		N/A	N/A	49.7	SD-MC18-01	1.65	81.9	81.9	1.65
NZTA1B2	9.4	0.5	5.0	SEV1A	0.68		N/A	N/A		N/A	N/A	5.0	SD-MC20-01	1.85	9.3	9.3	1.85
NZTA2A1	0.0	1.7		SEV2B1	0.54		N/A	N/A		N/A	N/A	0.0	Not Required	N/A	N/A	N/A	N/A
NZTA2A2	109.3	1.7	182.5	SEV2B1	0.54		N/A	N/A		N/A	N/A	182.5	SEV1	2.23	406.7	406.7	2.23
NZTA2A3	61.2	1.7	102.3	SEV2B1	0.54		N/A	N/A		N/A	N/A	102.3	SEV1	2.23	227.8	227.8	2.23
NZTA2A4	71.1	1.7	118.7	SEV2B1	0.54		N/A	N/A		N/A	N/A	118.7	SEV1	2.23	264.4	264.4	2.23
NZTA2B2	10.2	1.7	17.0	SEV2B1	0.54		N/A	N/A		N/A	N/A	17.0	SD-MC17A-02	1.31	22.3	22.3	1.31
NZTA2B3	98.7	1.7	164.8	SEV2B1	0.54	CU-17A	62.76	0.23	SEV1	1.28	134.6	60.0	SD-MC17A-02	1.31	78.8	213.4	1.30
NZTA2C1	20.3	0.3	5.3	SEV2C2	0.79		N/A	N/A		N/A	N/A	5.3	SD-MC17-05	2.08	11.0	11.0	2.08
NZTA3B3	47.7	0.3	12.9	SEV3A	0.73		N/A	N/A		N/A	N/A	12.9	SD-MC16-04	1.98	25.6	25.6	1.98
NZTA3B3a	6.0	0.1	0.8	SEV3A	0.73		N/A	N/A		N/A	N/A	0.8	Not Required	N/A	N/A	N/A	N/A
NZTA4A2	62.8	1.4	86.7	SEV4A 3 + 4	0.70		N/A	N/A		N/A	N/A	86.7	SEV2	3.85	333.7	333.7	3.85
NZTA4A3	1.6	1.4	2.2	SEV4A 3 + 4	0.70		N/A	N/A		N/A	N/A	2.2	SD-MC11-03	1.92	4.3	4.3	1.92
NZTA4A4	71.6	1.4	98.9	SEV4A 3 + 4	0.70		N/A	N/A		N/A	N/A	98.9	SD-MC10-03	1.94	192.0	192.0	1.94
NZTA4B1	39.9	0.4	16.8	SEV4A 3 + 4	0.70		N/A	N/A		N/A	N/A	16.8	SD-AC05A-01	1.77	29.7	29.7	1.77
NZTA4C1	15.9	0.6	8.7	SEV4F	0.77	CU-08A	15.9	0.23	SEV1	2.22	19.4	0.0	Not Required	N/A	N/A	N/A	N/A
NZTA4C2	12.0	0.6	6.6	SEV4F	0.77	CU-08A	12.0	0.23	SEV5	1.86	12.3	0.0	Not Required	N/A	N/A	N/A	N/A
NZTA4E1	26.4	0.6	16.4	SEV4F	0.77	CU-12	26.4	0.23	SEV5	1.86	30.5	0.0	Not Required	N/A	N/A	N/A	N/A
NZTA4E2	28.7	0.6	17.8	SEV4F	0.77	CU-12	28.7	0.23	SEV5	1.86	33.2	0.0	Not Required	N/A	N/A	N/A	N/A
NZTA4F2	9.8	0.3	3.1	SEV4F	0.77		N/A	N/A		N/A	N/A	3.1	SD-AC06-02	2.12	6.5	6.5	2.12
NZTA5A3	8.9	0.9	8.1	SEV5Aa u/s	0.79		N/A	N/A		N/A	N/A	8.1	SD-MC05-01	2.35	19.0	19.0	2.35
NZTA7A1	0.0	0.6		SEV7A1	0.82		N/A	N/A		N/A	N/A	0.0	Not Required	N/A	N/A	N/A	N/A
NZTA7A1	0.0	0.6		SEV7A1	0.82		N/A	N/A		N/A	N/A	0.0	Not Required	N/A	N/A	N/A	N/A

Impact data						Culvert effects							Infill effects			Summary offset data	
FullReachID	sloped_length	AverageWidth(m)	Total impact area (m2)	RepresentativeSEV	SEVi-P	Culvert name	Culvert length (m)	Culvert SEVi-I	Offset Location	Culvert ECR	(Culvert) Offset area required (m2)	Residual effects area (m2)	Offset Location	Infill ECR	(Infill) Offset area required (m2)	Total area to achieve no net loss	Average ratio (ECR)
NZTA7C1	0.0	1.4		SEV7B0	0.86		N/A	N/A		N/A	N/A	0.0	Not Required	N/A	N/A	N/A	N/A
NZTA8A1	80.5	0.9	72.4	SEV8A1	0.42	ACU-01	16.04	0.15	SEV4	1.58	22.9	58.0	SD-AC01-04	1.01	58.7	81.6	1.13
PD1A	47.4	0.5	25.3	SEV1A	0.68		N/A	N/A		N/A	N/A	25.3	SD-MC20-02	1.65	41.6	41.6	1.65
PD2C5	14.0	0.3	3.6	SEV2C2	0.79		N/A	N/A		N/A	N/A	3.6	SD-MC17-05	2.08	7.5	7.5	2.08
PD2C6	15.0	0.3	3.9	SEV2C2	0.79		N/A	N/A		N/A	N/A	3.9	SD-MC17-05	2.08	8.1	8.1	2.08
PD3B1	4.1	0.2	0.7	SEV3A	0.73		N/A	N/A		N/A	N/A	0.7	Not Required	N/A	N/A	N/A	N/A
PD3B2	13.5	0.2	2.3	SEV3A	0.73		N/A	N/A		N/A	N/A	2.3	SEV2	3.97	9.1	9.1	3.97
PD4A11	34.9	1.4	48.1	SEV4A 3 + 4	0.70		N/A	N/A		N/A	N/A	48.1	SEV2	3.85	185.2	185.2	3.85
PD4A12	43.8	1.4	60.4	SEV4A 3 + 4	0.70		N/A	N/A		N/A	N/A	60.4	SEV2	3.85	232.5	232.5	3.85
PD4A13	0.7	1.4	1.0	SEV4A 3 + 4	0.70		N/A	N/A		N/A	N/A	1.0	SEV2	3.85	3.9	3.9	3.85
PD4A14	26.4	1.4	36.5	SEV4A 3 + 4	0.70		N/A	N/A		N/A	N/A	36.5	SD-MC10-03	1.94	70.9	70.9	1.94
PD4A15	30.5	1.4	42.2	SEV4A 3 + 4	0.70		N/A	N/A		N/A	N/A	42.2	SEV2	3.85	162.2	162.2	3.85
PD4B1	70.0	0.4	29.4	SEV4A 3 + 4	0.70		N/A	N/A		N/A	N/A	29.4	SD-AC05A-01	1.77	52.1	52.1	1.77
PD4C1	41.9	0.6	23.0	SEV4F	0.77		N/A	N/A		N/A	N/A	23.0	SEV2	4.21	96.9	96.9	4.21
PD4C2	20.5	0.6	11.3	SEV4F	0.77		N/A	N/A		N/A	N/A	11.3	SD-MC09-03	2.12	23.9	23.9	2.12
PD4C3	8.5	0.6	4.7	SEV4F	0.77		N/A	N/A		N/A	N/A	4.7	SD-MC09-03	2.12	9.9	9.9	2.12
PD5A7	21.2	0.3	5.9	SEV5Aa u/s	0.79		N/A	N/A		N/A	N/A	5.9	SD-MC05-01	2.35	14.0	14.0	2.35
PD5A8	42.7	0.3	11.9	SEV5Aa u/s	0.79		N/A	N/A		N/A	N/A	11.9	SD-MC05-01	2.35	28.0	28.0	2.35
PD5B1A	105.0	0.3	28.3	SEV5B6	0.75		N/A	N/A		N/A	N/A	28.3	SD-MC05-01	2.21	62.8	62.8	2.21
PD5B2	81.5	0.3	22.0	SEV5B7	0.77	ACU-04	82.9	0.23	SEV1	2.21	49.6	-0.4	Not Required	N/A	N/A	N/A	N/A
PD9A1	10.1	0.9	8.8	SEV7B 1 +2	0.86		N/A	N/A		N/A	N/A	8.8	SEV5	2.96	26.1	26.1	2.96